

AD627040

KLICKITAT

LONG RANGE SEISMIC MEASUREMENTS

# KLICKITAT

20 FEBRUARY 1964

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER

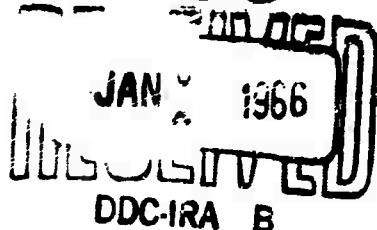
Washington, D. C.

24 NOVEMBER 1965

By

UED EARTH SCIENCES DIVISION  
TELEDYNE, INC.

-- DDC



Under

Project VELA UNIFORM

ARCHIVE COPY

Sponsored By

Code 1 : ADVANCED RESEARCH PROJECTS AGENCY  
Nuclear Test Detection Office  
ARPA Order No. 624

CLEARINGHOUSE  
FEDERAL SCIENTIFIC AND  
TECHNICAL INFORMATION  
rdcopy Microfilm:  
2.00 \$0.50 34 A

**BEST  
AVAILABLE COPY**

LONG RANGE SEISMIC MEASUREMENTS  
KLICKITAT

20 February 1964

SEISMIC DATA LABORATORY REPORT NO. 131

AFTAC Project No.: VELA T/2037  
Pro Title: Seismic Data Laboratory  
ARPA Order No.: 624  
ARPA Program Code No.: 5810

Name of Contractor: UED EARTH SCIENCES DIVISION  
TELEDYNE, INC.

Contract No.: AF 33(657) 12447  
Date of Contract: 17 August 1963  
Amount of Contract: \$ 5,382,624  
Contract Expiration Date: 17 February 1966  
Project Manager: Robert Van Nostrand  
(703) 836 - 7644

P. O. Box 334, Alexandria, Virginia

AVAILABILITY

Qualified Users May Request Copies of This Document From:

Defense Documentation Center  
Cameron Station  
Alexandria, Virginia 22314

This research was supported by the Advanced Research Projects Agency, Nuclear Test Detection Office, and was monitored by the Air Force Technical Applications Center under Contract AF 33(657) 12447.

Neither the Advanced Research Projects Agency nor the Air Force Technical Applications Center will be responsible for information contained herein which may have been supplied by other organizations or contractors, and this document is subject to later revision as may be necessary.

## TABLE OF CONTENTS

	Page No.
Event Description	1
Introduction	2
Instrumentation and Procedure	2
Data and Results	5
 Tables	
1      Station Status Report - KLICKiTAT	
2      Principal Phases - KLICKiTAT	
 Figures	
1      Recording Stations and Signals Received	
2      Unified Magnitudes	
3      Travel-Time Residuals, $T - \Delta/8.1$ ; $T - JB$	
4      Maximum Amplitudes of Pn and P	
5      Maximum Amplitudes of Pg	
6      Maximum Amplitudes of Lg	
7      Maximum Amplitudes of LQ	
8      Maximum Amplitudes of LR	
 List of Appendices	
I(A)    Recording Site Information	
I(B)    Unified Magnitudes from Pn or P Waves	
II      Seismic Analysis Diagram	
III     First Motion Criteria (TWG II)	
LP and SP Response Curves	

**BLANK PAGE**

KLICKITAT  
EVENT DESCRIPTION

DATE: 20 February 1964

TIME OF ORIGIN: 15:30:00.1Z

YIELD:

MAGNITUDE: 4.95 ± 0.40

LOCATION:

Site: Nevada Test Site - Area Ul0e

Geographic Coordinates:

Lat: 37°09'03" N

Long: 116°02'24" W

ENVIRONMENT:

Geologic Medium: Tuff

Surface Elevation: 4266 Feet

Shot Elevation: 2641 Feet

Shot Depth: 1625 Feet

COMPUTED EPICENTER: All Stations

Geographic Coordinates:

Lat: 37°08'46" N

Long: 116°07'05" W

Time of Origin: 15:30:04.9Z

Dept: 41 Km

Epicenter Shift: 6.9 Km, N 266° E

Code	Station	Final							Tape	Timing
		SPZ	SPR	SPT	LPT	LPR	LPT			
CU-NV	Currant, Nevada	+	+	+	+	+	+	+	*	P
EK-NV	Eureka, Nevada	+	+	+	+	+	+	+	*	P
MN-NV	Mina, Nevada	+	+	+	+	+	+	+	*	P
KM-CL	Kramer, California	+	+	+	+	+	+	+	*	P
KN-UT	Kanab, Utah	+	+	+	+	+	+	+	*	P
CP-CL	Campo, California	+	+	-	+	+	+	+	*	P
TF80	Tonto Forest Observatory, Arizona	+	+	+	+	+	+	+	*	P
BX-UT	Blanding, Utah	+	+	+	+	+	+	+	*	P
UBSO	Uinta Basin Observatory, Utah	+	+	+	+	+	+	+	*	P
DR-CO	Durango, Colorado	+	+	+	+	+	+	+	*	P
HL-ID	Hailey, Idaho	+	+	+	+	+	+	+	*	P
PI-WY	Pinedale, Wyoming	+	+	+	N	N	N	*	*	P
BMSO	Blue Mountain Observatory, Oregon	+	+	+	+	+	+	+	*	P
LC-NM	Laa Cruces, New Mexico	+	+	+	+	+	I	*	S	
RT-NM	Raton, New Mexico	+	+	+	+	+	+	+	*	P
FR-MT	Forayth, Montana	+	+	+	+	+	+	+	*	P
AZ-TX	Amarillo, Texas	?	+	+	+	+	+	+	*	P
TK-WA	Tonasket, Washington	+	+	+	+	+	+	+	*	P
SK-TX	Shamrock, Texas	+	+	+	+	+	-	*	*	P
GI-MT	Glendive, Montana	+	+	+	+	+	-	e	P	
WMSO	Wichita Mountain Observatory, Oklahoma	+	+	+	+	+	+	+	*	P
RY-ND	Hydar, North Dakota	+	+	+	-	-	-	*	*	P
GV-TX	Grapevine, Texas	-	-	-	+	N	N	*	*	P
DU-OK	Durant, Oklahoma	+	+	+	+	+	-	*	*	P
HH-ND	Hannah, North Dakota	+	+	+	+	+	-	*	*	P
HE-TX	Hampstead, Texas	+	+	-	N	N	N	*	S	
EB-MT	Saat Braintrae, Manitoba, Canada	+	+	+	-	-	-	*	*	P
JE-LA	Jena, Louisiana	-	-	-	+	-	-	*	P	
RK-ON	Red Laka, Ontario, Canada	+	+	+	I	-	-	*	*	P
EU-AL	Eutaw, Alabama	-	-	+	+	-	-	*	S	
CPOO	Cumberland Plateau Observatory, Tennessee	+	+	+	+	+	+	*	*	P
BL-WV	Beckley, West Virginia	+	-	-	-	-	-	*	P	
BR-PA	Berlin, Pennsylvania	+	+	+	-	-	-	*	P	
DH-NY	Delhi, New York	+	-	-	-	-	-	*	P	
LS-NH	Liabon, New Hampshire	-	-	-	-	-	-	*	P	
HN-ME	Houlton, Maine	+	-	-	-	-	-	*	P	
HW-IS	Kamuela, Hawaii	-	-	-	-	-	-	*	P	
NP-NT	Mould Bay, Northwest Territories, Canada	+	-	-	-	-	-	*	P	
GM-CU	Guantanamo, Cuba	-	-	-	-	-	-	*	P	
PZ-PR	Ponce, Puerto Rico	+	-	-	-	-	-	*	P	
LZ-BV	La Paz, Bolivia	+	-	-	-	-	-	*	P	
OO-NW	Oalo, Norway	+	-	-	-	-	-	*	P	
SB-GR	Grafanberg, Germany	-	-	-	-	-	-	*	P	

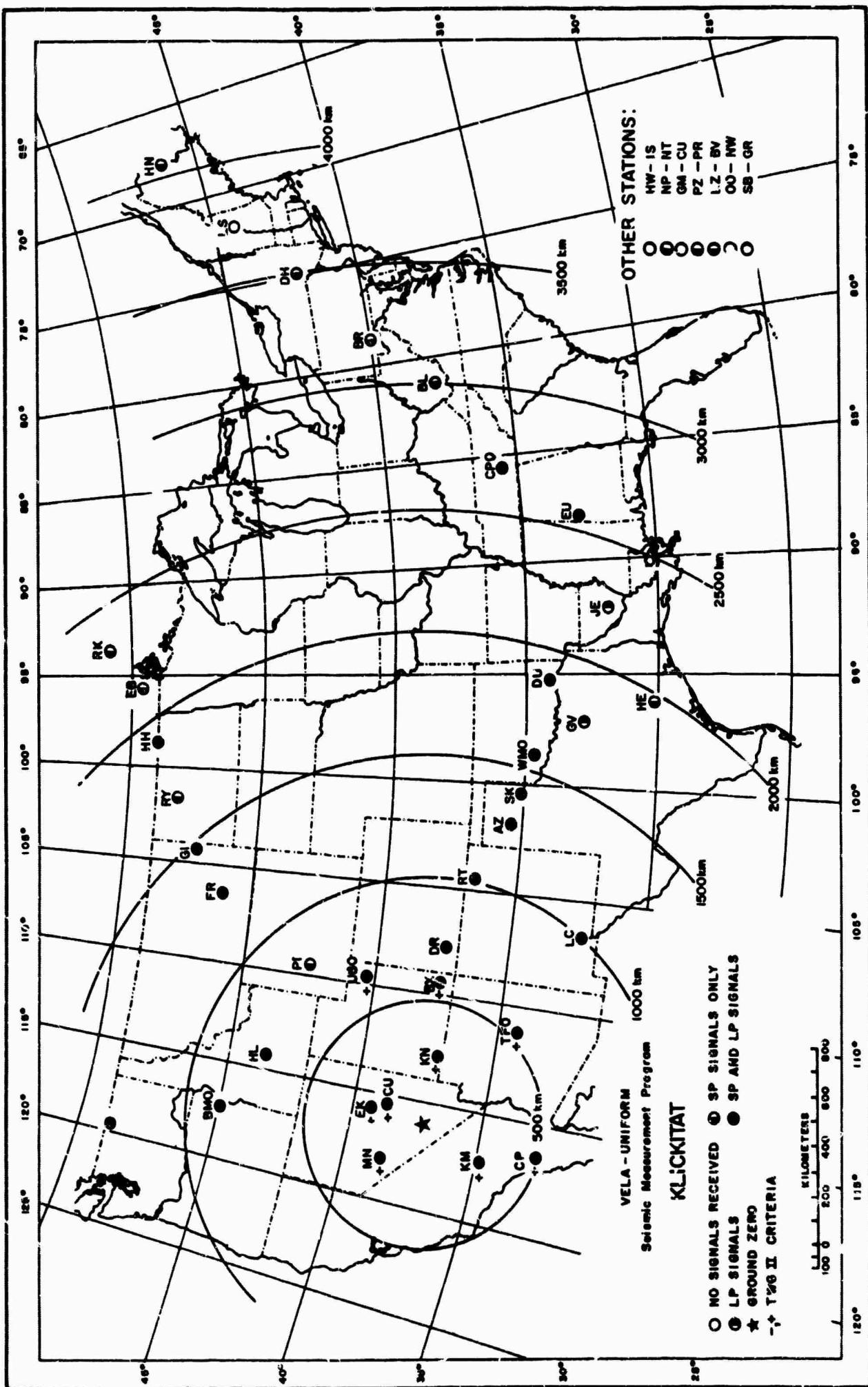
I Inoperativa      ? Questionable Signal  
 N No Instruments    + Signal  
 P Primary Timing    - No Signal  
 S Secondary Timing   \* Magnetic Tape Available

## Station Status Report - KLICKITAT

Table 1

Figure 1

## Recording Stations and Signals Received



### Introduction

A long range seismic measurements (LRSM) program was established under VELA-UNIFORM to record and analyze short-period and long-period data from a planned series of U. S. underground nuclear tests. These, and other data, will be used by VELA-UNIFORM participants for studying and developing methods for distinguishing between explosive and earthquake sources.

The purpose of this report is to provide an analysis of data resulting from the KLICKITAT event from the LRSM film seismograms from operating mobile field teams; Wichita Mountain Observatory, Oklahoma (WMSO), Uinta Basin Observatory, Utah (UBSO), Blue Mountain Observatory, Oregon (BMSO), Cumberland Plateau Observatory, Tennessee (CPSO), and Tonto Forest Observatory, Arizona (TFSO); and from several experimental or temporary stations operated in connection with other research programs.

### Instrumentation and Procedure

Instrumentation at each of the mobile stations consists of three-component short-period Benioff and three-component Sprengnether long-period seismographs. Data are recorded on 35 millimeter film and on one-inch 14-channel

magnetic tape. All of these stations are equipped to record WWV continuously in order to provide accurate time control. Calibration is accomplished once each day and just prior to each shot at operating settings. Specific details of the instrumentation and operating procedures for these stations are given in Field Manual, Long Range Seismic Measurement Program, Technical Report No. 63-17, which can be obtained from the Geotech Division of Teledyne Industries, Inc., Dallas, Texas. All the observatories have both long-period and short-period, three-component instrumentation in addition to their other specialized facilities.

Station site information is presented in Appendix I(A). This includes the station name and code; the geographic coordinates, distances and azimuths involved; the station elevations; and the type of instruments in use at each location.

A status report for KLICKITAT is included in Table 1, placed opposite the operations map, Figure 1. This report gives the names of 43 stations and indicates which instruments were operational and which recorded usable signals.

An explanation of the procedure for amplitude measurements used in this report is illustrated in Appendix II. The unified magnitude ( $m$ ) computations for distances less than

$16^{\circ}$  are based on AFTAC/VSC extensions of Gutenberg's Tables\*. For this purpose, points from  $10^{\circ}$  to  $16^{\circ}$  were read from a curve in the Gutenberg-Richter paper and an inverse cube relationship was used to extrapolate from two to ten degrees.

A table of the distance factors (B) is provided in Appendix I(B).

Appendix III quotes the Technical Working Group II (TWG II) first motion criteria, and includes diagrams illustrating the elements involved in determining a compression or rarefaction where satisfactory measurements can be made.

A standard hypocenter location program for a digital computer has been used to determine the location using data from all stations analyzed. Best-fit values of latitude, longitude, depth of focus, and time of origin are determined statistically by a least squares technique. This utilizes a Jeffreys-Bullen travel-time curve as modified by Herrin in 1961 on the basis of Pacific surface-focus recordings. Precision of the computation is limited primarily by the accuracy of arrival times, the validity of the standard travel-time curve, and local velocity deviations. Since the method is based on P wave arrivals, this particular program does not

---

\*Gutenberg, B. and Richter, C. F. Magnitude and Energy of Earthquakes, Ann. Geofis., 9 (1956), pp. 1-15.

make use of later phases such as pP and S in the determination of depth or location. Results are shown on the Event Description page.

#### Data and Results

Table 2 summarizes the measurements made of the principal phases from the KLICKITAT event. Included are the Pn and P arrival times, the maximum amplitudes (A/T) of Pn or P and Pg motion as seen on the short-period vertical instruments, and the maximum amplitudes (A/T) of the Lg phase as measured on the short-period horizontal tangential component. Long-period Love and Rayleigh wave motion are also tabulated in (A/T) form. Thirty-five stations recorded short-period signals. Long-period signals from this event were recorded by twenty-six stations.

In addition, Table 2 and Figure 2 show the unified magnitudes ( $m$ ) where measurable. The average magnitude for KLICKITAT is 4.95. PZ-PR with an anomalies magnitude of 6.12 is not included in this average nor in Figure 2 for  $\Delta > 16^\circ$ . Nine stations show compressional first motion as defined by the First Motion Criteria (TWG II).

The travel-time residuals from the Pn and P phase are within the usual limits (see Figure 3). The amplitudes

of Pn and P, Pg and Lg are shown in Figures 4, 5 and 6. Lines proportional to the inverse cube of the distance visually fitted through the observed points are shown on these graphs. Love and Rayleigh wave amplitudes are shown in Figures 7 and 8.

Attached to the report are illustrative seismograms showing the signals recorded at a number of locations. The most distant station analyzed that recorded KLICKITAT was LZ-BV at a distance of 7725 kilometers.

Principal Phases  
KLICKITAT  
20 February 1964  
15:30:00.1Z

Code	Station	Distance (km)	Inst.	Magni-fication (k) Film x 10	Phase	Observed Travel Time		Period T (sec)	Maximum Amplitude A/T	TNG II First Motion	Magni-tude (m)
						(min)	(sec)				
CU-NV	Currant, Nevada	177	SPZ	1.08	Pn	0	28.7	0.8	1225	C	
			SPZ	1.08	e	0	29.9	0.5	2933		
			SPZ	1.08	Pg	0	30.7	0.5	6704		
			SPT	1.08	Lg			0.6	8374		
			LPT	22.0	Lo			10.0	567		
			LPZ	21.5	LR			16.0	192		
EK-NV	Eureka, Nevada	230	SPZ	2.75	Pn	0	36.0	0.55	567	C	4.99
			SPZ	2.75	e	0	36.7	0.4	627		
			SPZ	2.75	Pg	0	38.6	0.4	4014		
			SPZ	2.75	e	0	42.5	0.6	4550		
			SPT	2.46	Lg			0.7	10,700		
			LPT	31.2	Lo			12.0	406		
MN-NV	Mira, Nevada	234	SPZ	3.70	Pn	0	36.3	0.5	1786	C	5.50
			SPZ	3.70	Pg		---	---	---		
			SPT	3.50	Lg			0.8	6,510		
			LPT	26.8	Lo			10.0	928		
			LPZ	2.59	LR			14.0	396		
			SPZ	4.44	Pn	0	41.4	0.6	615		
KM-CL	Kramer, California	275	SPZ	4.44	e	0	43.3	0.5	693	C	5.25
			SPZ	4.44	Pg	0	46.8	0.8	1966		
			SPZ	9.33	Lg			0.8	4490		
			LPT	12.7	Lo			13.0	277		
			LPZ	15.4	LR			14.0	209		
			SPZ	5.65	Pn	0	42.9	0.6	635		
KN-UT	Kanab, Utah	286	SPZ	5.65	e	0	43.6	0.5	865	C	5.28
			SPZ	5.65	Pg	0	47.2	0.6	5923		
			SPZ	5.65	Lg			0.6	6585		
			SPT	5.16	Lo			13.0	242		
			LPT	34.6	Lo			14.0	219		
			LPZ	34.0	LR						
CP-CL	Campo, California	491	SPZ	9.64	Pn	1	08.3	0.4	43.6	C	4.86
			SPZ	9.64	e	1	09.1	0.6	337		
			SPZ	9.64	Pg	1	19.9	0.8	514		
			SPT	12.95	Lg			0.8	390		
			LPT	10.03	Lo			13.0	95.7		
			LPZ	1.05	LR			11.0	360		
TFSO	Tonto Forest Observatory, Arizona	536	SPZ-74	157.5	Pn	1	14.9	0.45	20.4	C	4.66
			SPZ-1	38.0	e	1	24.3	0.5	592		
			SPZ-1	38.0	Pg	1	29.9	0.7	446		
			SPN	31.5	Lg			1.2	477		
			LPZ	2.9	LR			17.0	105		
			SPZ	16.85	Pn	1	20.3	0.4	217		
BX-UT	Blanding, Utah	587	SPZ	16.85	e	1	21.6	0.4	17	C	5.79
			SPZ	16.85	Pg	1	36.9	0.5	1429		
			SPZ	16.85	Lg			0.6	1449		
			SPT	16.4	Lo			13.0	138		
			LPT	4.6	Lo			13.0	188		
			LPZ	5.1	LR						
UBSO	Uinta Basin Observatory, Utah	664	SPZ-10	10.2	Pn	1	33.4	(0.6)	(45.4)	C	(5.25)
			SPZ-10	10.2	e	1	34.3	0.6	250		
			SPZ-10	10.2	Pg	1	50.9	0.7	437		
			SPE	10.8	Lg			1.2	438		
			LPZ	23.5	LR			12.0	105		
			SPZ	39.5	Pn	1	38.1	0.6	13.0		
DR-CO	Durango, Colorado	732	SPZ	39.5	e	1	40.5	0.5	43.5	C	4.83
			SPZ	39.5	Pg	1	59.9	0.6	415		
			SPZ	39.5	Lg			0.8	415		
			SPT	37.0	Lo			(17.0)	(42.5)		
			LPT	20.0	Lo			14.0	88.1		
			LPZ	20.9	LR						
HL-ID	Hailey, Idaho	737	SPZ	41.5	Pn	1	39.6	0.8	8.86	C	4.68
			SPZ	41.5	e	1	42.5	0.6	28.8		
			SPZ	41.5	Pg	2	00.9	0.4	431		
			SPT	40.4	Lg			0.5	309		
			LPT	20.7	Lo			13.0	108		
			LPZ	22.8	LR			12.0	177		
PI-WY	Pinedala, Wyoming	809	SPZ	64.5	Pn	1	50.4	0.6	47.7	C	5.54
			SPZ	64.5	e	1	51.9	0.9	160		
			SPZ	64.5	Pg	2	13.1	0.8	254		
			SPT	52.7	Lg			(1.0)	(716)		
			SPZ-3	28.0	Pn	1	57.1	0.6	10.1		
			SPZ-3	28.0	e	1	59.4	0.9	28.9		
BMSO	Blue Mountain Observatory, Oregon	962	SPZ-3	28.0	Pg	2	06.9	0.6	129	C	4.95
			SPZ-3	28.0	Lg		(23.9)	(0.8)	(111)		
			SPZ-3	28.0	Lo			1.0	236		
			SPE	38.1	Lo			13.5	102		
			LPZ	6.8	LR			15.0	82.7		
			LPZ	31.0	LR						

### Principal Phases - KLICKITAT

Table 2 - Page 1

Principal Phases  
KLICKITAT  
20 February 1964  
19:30:00.16

Code	Station	Distance (km)	Inet.	Magnification (k) Pm x 10	Phase	Observed Travel Time		Period T (sec)	Maximum Amplitude A/T	Mug II First Motion	Magnitude (m)
						(min)	(sec)				
LC-NM	Las Cruces, New Mexico	1011	SPZ	105.5	Pn	2	17.6	1.0	7.09		5.06
			SPG	105.5	Pg	2	48.4	1.0	151		
			GPT	104.5	Lg			1.1	147		
			LPG	32.6	LR			13.0	102		
RT-NM	Raton, New Mexico	1041	SPZ	132	(Pn)	2	16.2	0.6	(3.90)		(4.02)
			SPG	132	*	2	24.0	(1.0)	(13.3)		
			SPZ	132	*	2	43.5	.6	25.0		
			SPG	132	Pg	2	(54.0)	.6	96.0		
			GPT	130	Lg			1.3	100		
PR-MT	Forayth, Montana	1275	SPZ	131.9	P	3	45.6	0.8	34.8		5.69
			GPT	118.4	Lg			1.1	99		
			LPG	20.3	LR			13.0	74.5		
AZ-TX	Amarillo, Texas	1281	GPT	37.6	Lg			(1.2)	(229)		
			LPG	17.8	LR			17.0	35.4		
TK-WA	Tonasket, Washington	1326	SPZ	229.4	P	2	54.2	0.8	9.20		5.07
			SPG	229.4	*	3	45.0	(1.0)	(14.2)		
			GPT	226.	Lg			1.3	52.6		
			LPG	37.7	LR			14.0	58.7		
SK-TX	Shamrock, Texas	1428	SPZ	156	P	3	(46.7)	(1.0)	(40.7)		(5.63)
			SPG	156	Pg	3	58.9	(1.0)	(84.9)		
			GPT	140	Lg			(1.4)	(189)		
			LPG	14.8	LR			17.0	20.4		
OI-MT	Glendive, Montana	1480	SPZ	108	P	3	10.1	0.8	16.3		5.09
			SPG	108	*	3	21.5	0.8	27.2		
			GPT	110	Lg			1.0	(84.1)		
			LPG	8.03	LR			13.	43.6		
WMBO	Wichita Mountain Observatory, Oklahoma	1595	SPZ-6	150	P	3	(26.7)	1.2	23.2		4.86
			SPZ-6	150	*	3	34.9	(1.2)	(15.4)		
			SPZ-6	150	Pg	4	(43.9)	1.1	52.6		
			SPW	160	Lg			7.5	(154)		
			LPH	22	LQ			16.0	42.5		
			LPG	17.5	LR			16.0	43.2		
RY-ND	Ryder, North Dakota	1699	SPZ	30.2	P	3	(38.6)	(0.8)	(18.3)		(4.75)
			SPZ	30.2	*	3	44.2	0.8	158		
GV-TX	Grapevine, Texas	1796	LPG	10.55	LR			14.0	66.9		
DU-OK	Durant, Oklahoma	1826	SPZ	106	P	3	53.0	(1.0)	(64.8)		(4.71)
			SPZ	106	*	4	13.3	(0.6)	(24.2)		
			GPT	106	Lg			(1.2)	(156)		
			LPG	7.0	LR			13.0	39.5		
HE-ND	Mannah, North Dakota	1920	SPZ	33.4	P	4	02.9	(1.0)	(22.5)		(4.25)
			SPZ	33.4	*	4	05.0	1.1	202		
			GPT	31.0	(Lg)			(1.6)	(188)		
			LPG	11.3	LR			10.0	116		
HE-TX	Hempstead, Texas	1999	SPZ	52.7	P	4	13.4	1.0	43.4		4.54
EB-MT	Saskatchewan, Manitoba, Canada	2147	SPZ	216	P	4	26.9	0.85	14.6		4.23
			GPT	193	Lg			1.5	36..		
JB-LA	Jana, Louisiana	2279	LPG	9.92	LR			12.0	143		
RK-ON	Red Lake, Ontario, Canada	2337	SPZ	201	P	4	45.3	0.95	141		5.25
			SPZ	201	*	4	52.9	0.8	302		
			GPT	189	Lg			(1.6)	(71.2)		
EU-AL	Eutaw, Alabama	2607	GPT	73.3	Lg			2.0	176		
			LPG	8.15	LR			13.0	78.5		
CPBO	Cumberland Plateau Observatory, Tennessee	2728	SPZ-8	310	P	5	21.0	0.7	20.2		4.72
			SPW	330	Lg			1.7	76		
			LPH	11.0	LQ			17.0	17.6		
			LPG	10.0	LR			14.0	42.9		
GL-WV	Beckley, West Virginia	3056	SPZ	58.1	P	5	48.3	0.8	12.6		4.65
BR-PA	Berlin, Pennsylvania	3235	SPZ	137.5	P	6	(02.7)	0.8	12.0		4.60
			GPT	121.3	Lg			2.0	93.2		
DH-NY	Dalhi, New York	3541	SPZ	51.7	P	6	26.5	0.7	13.3		
HM-ME	Moulton, Maine	4062	SPZ	133	P	7	(10.1)	0.75	7.90		4.45
			GPT	184	*	7	33.0	0.9	25.2		
PZ-PR	Ponca, Puerto Rico	52.9	SPZ	15.3	P	6	(37.9)	(0.6)	(166)		(6.12)
			GPT	181	P	11	11.2	0.7	4.45		
LZ-BV	La Paz, Bolivia	7725	SPZ-1								4.60

A/T mu/sec

C Compressional

( ) Doubtful Values or Phases

--- Signal not Measurable because of Excessive Amplitude or Amplitude Clipping

## Principal Phases - KLICKITAT

Table 2 - Page 2

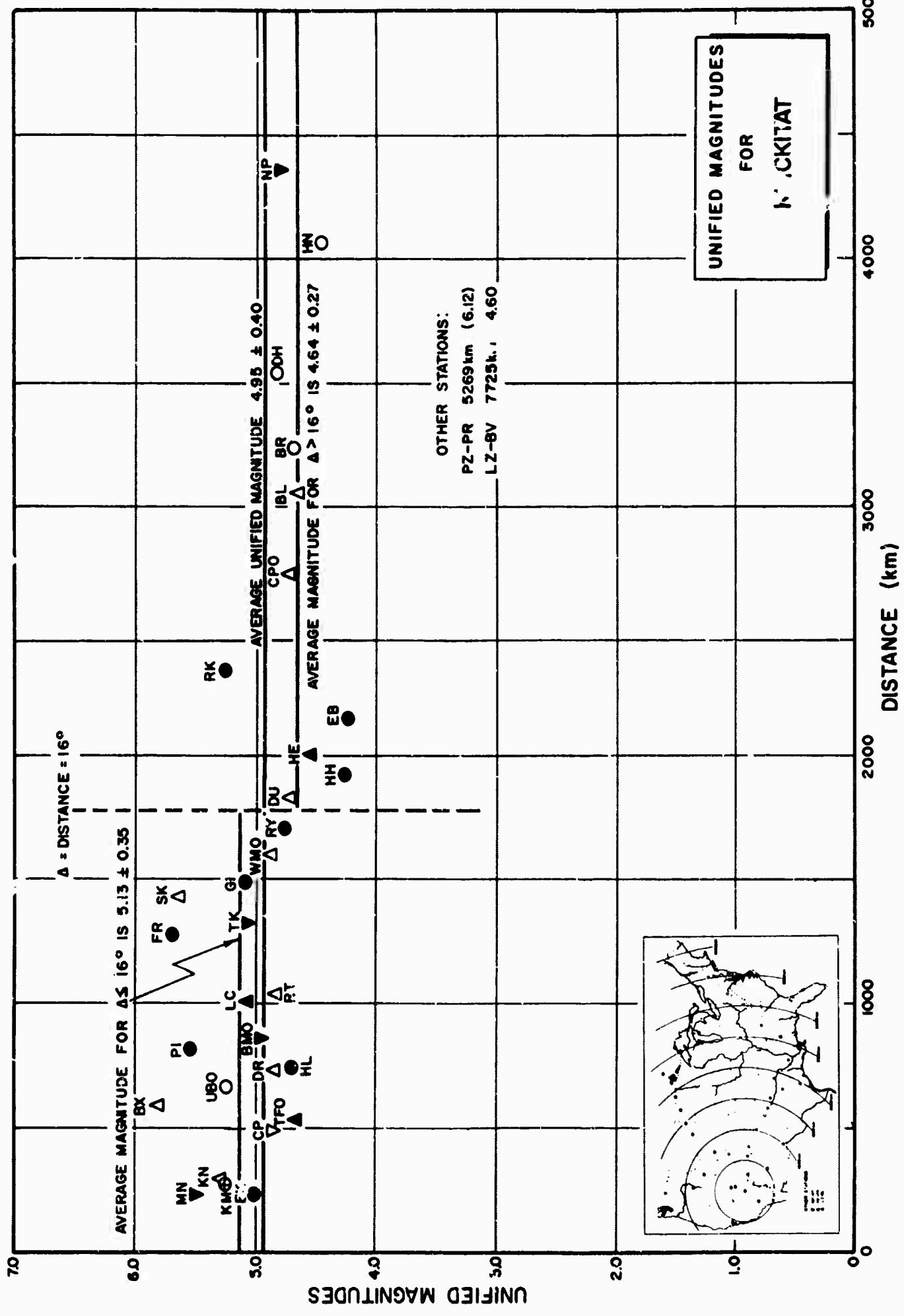


Figure 2

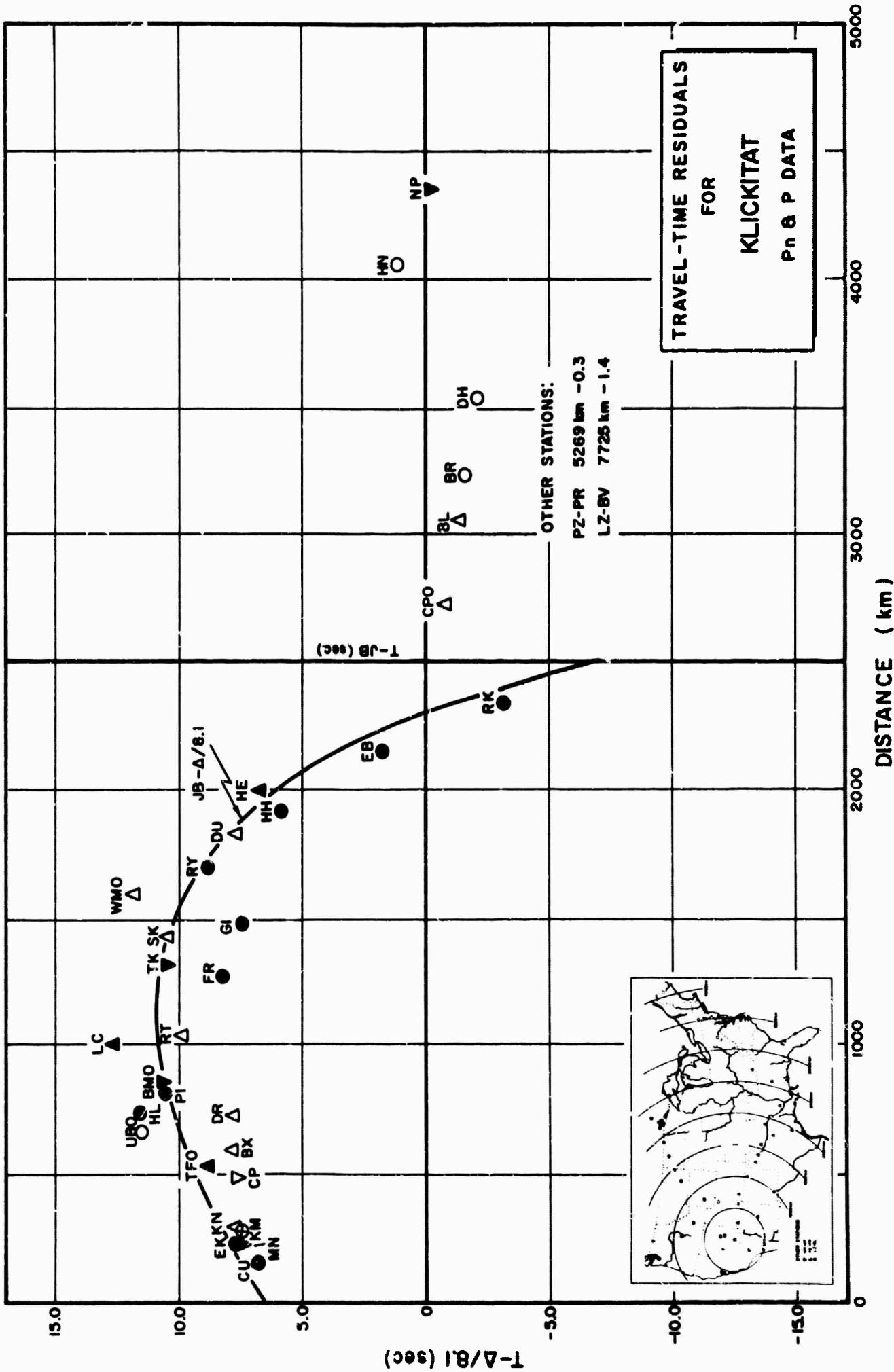


Figure 3

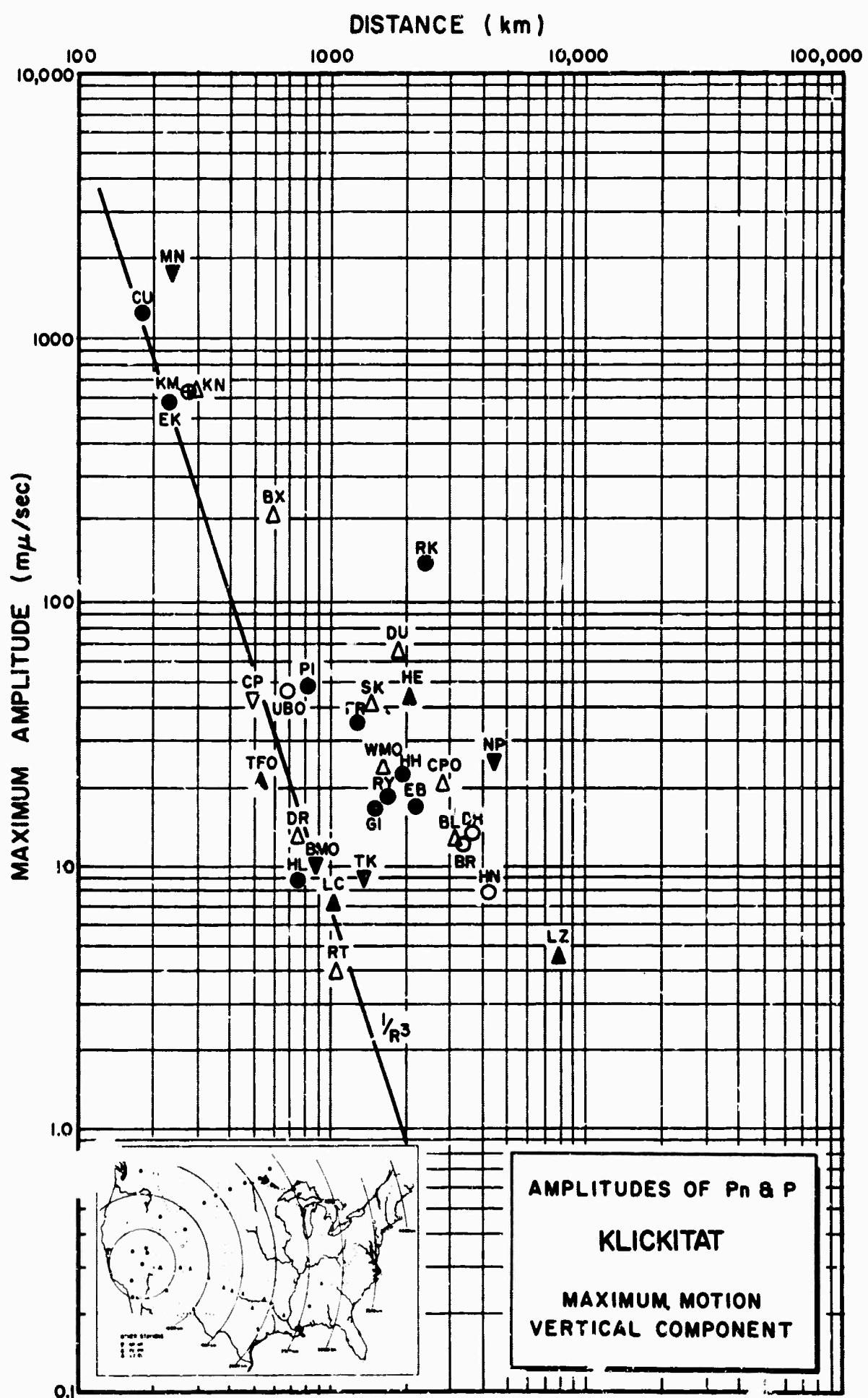


Figure 4

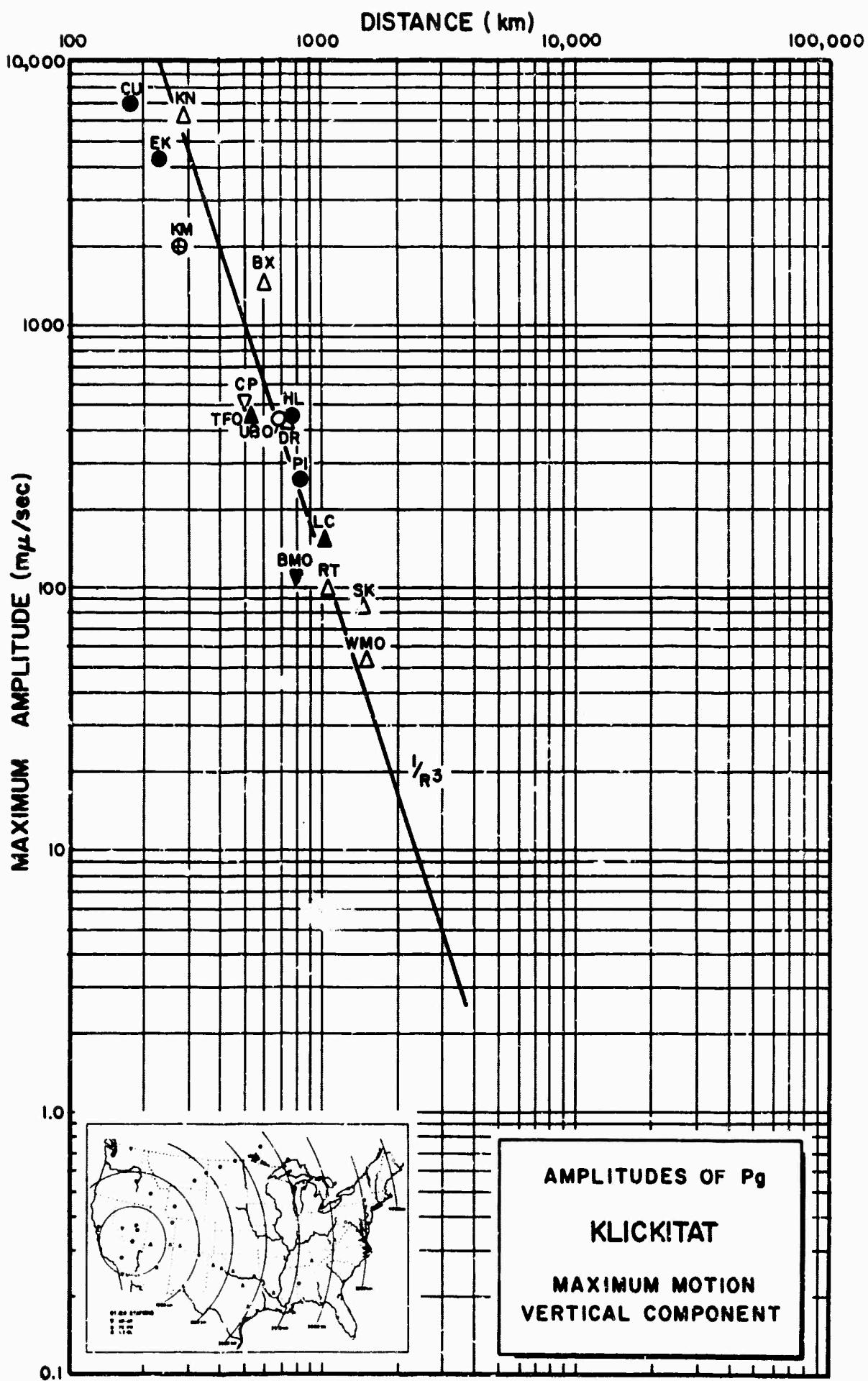


Figure 5

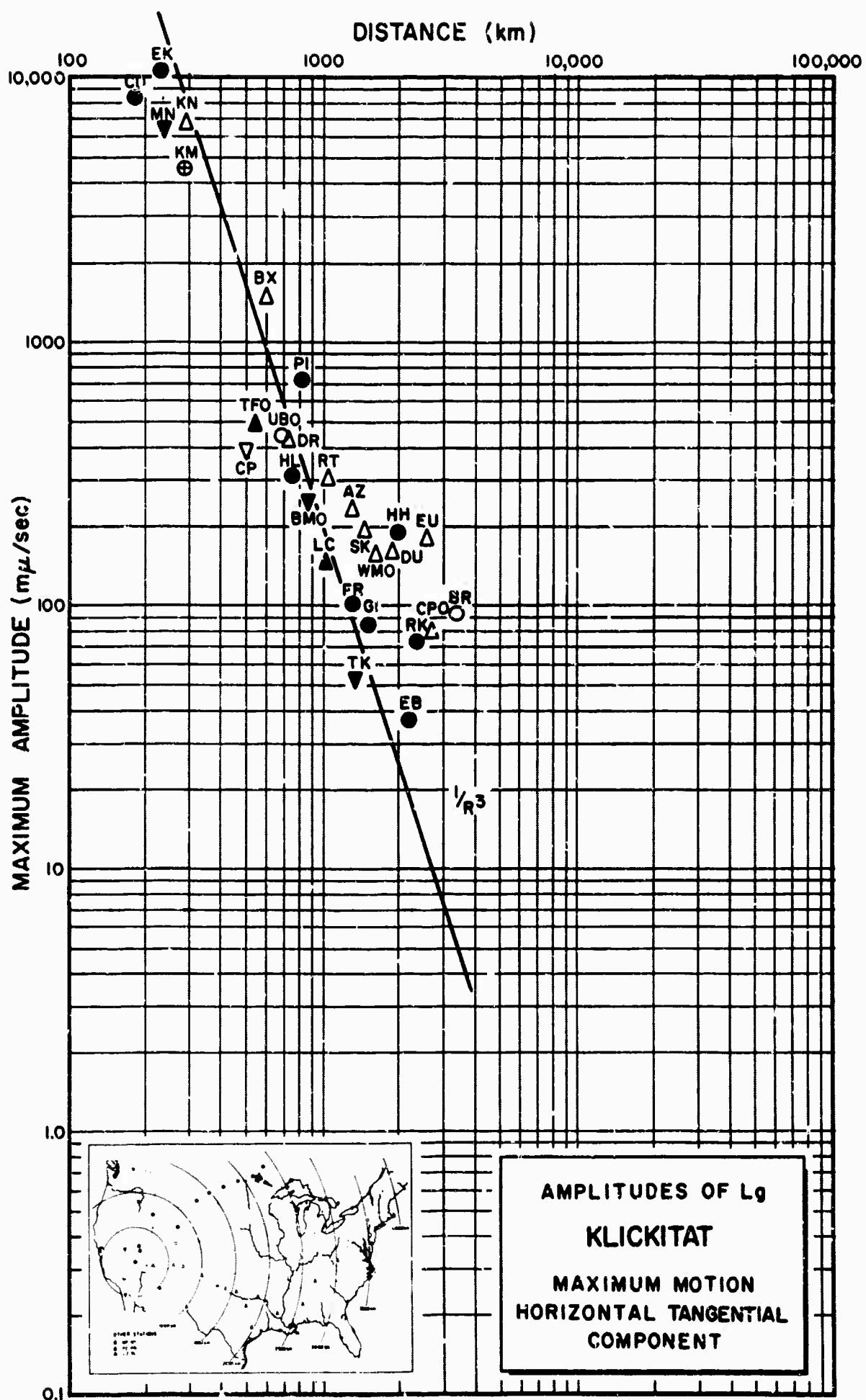


Figure 6

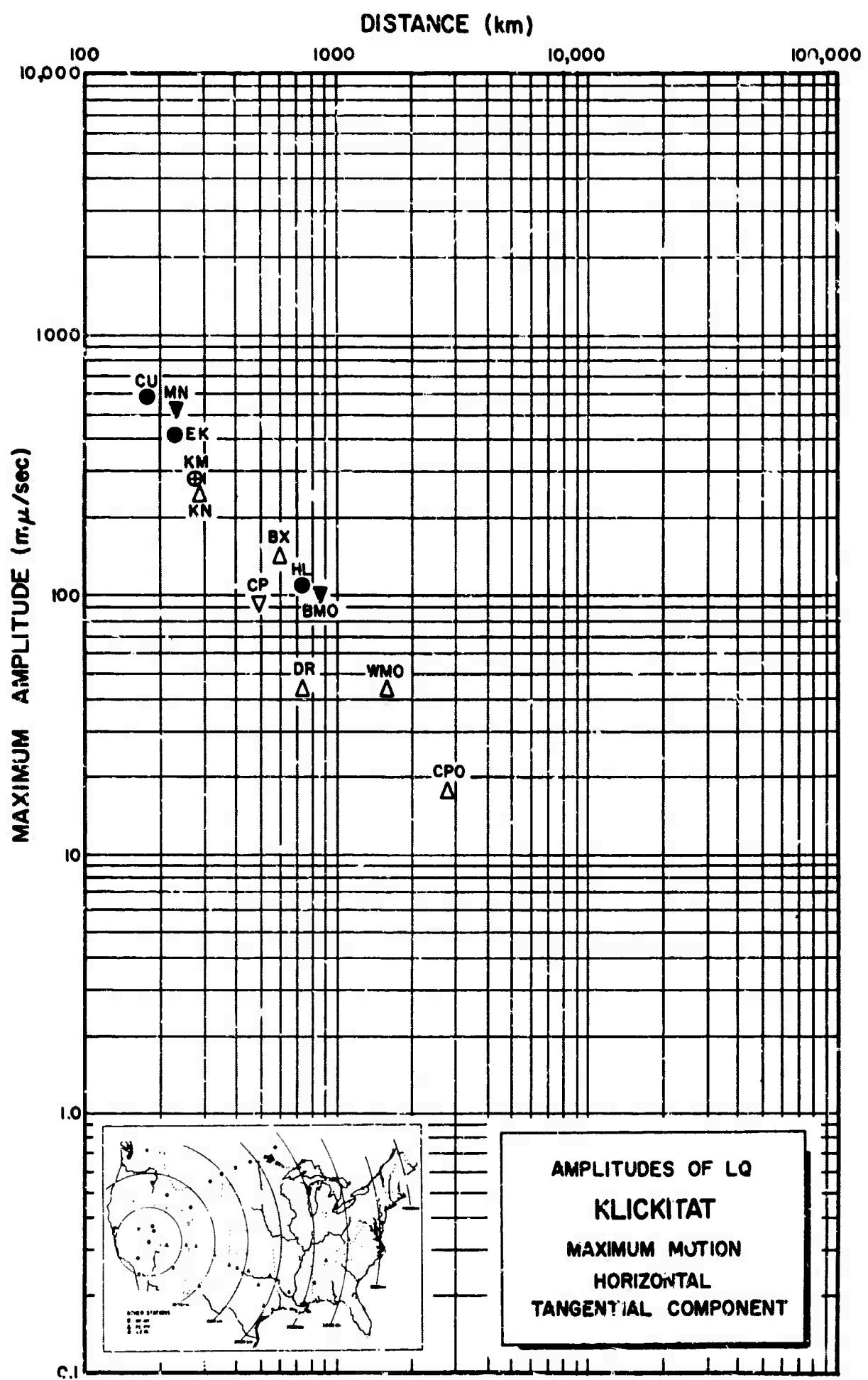


Figure 7

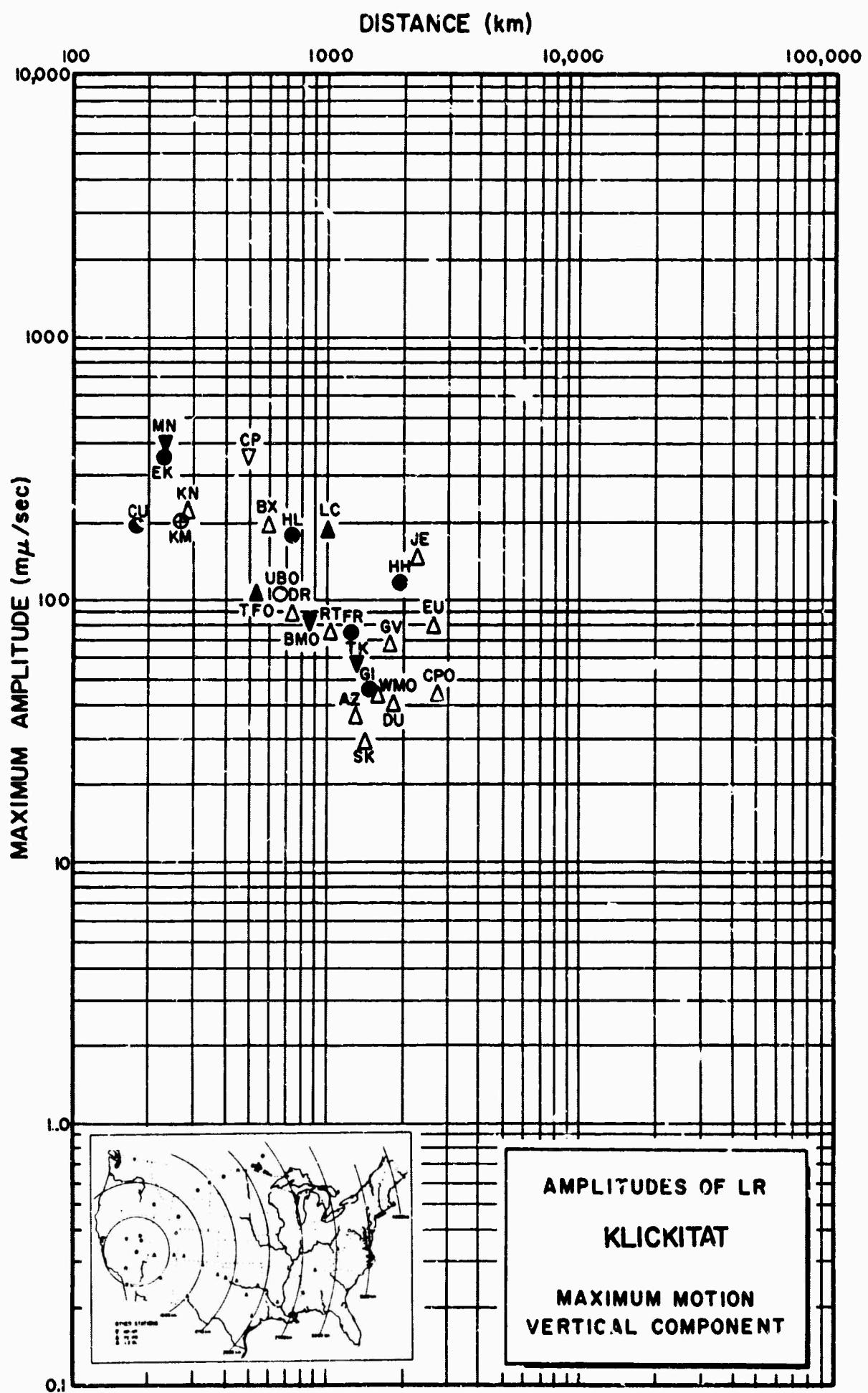


Figure 8

Code	Station	Distance (km)	Geographic Latitude	Geographic Longitude	Elev. (km)	Computed Azimuth		Installed Azimuth		Large or Small SP	LP Inst.
						Epi. Sta.	Sta. Epi.	Radial	Tang.		
CU-NV	Carson, Nevada	177	38°40'38" N	115°27'18" W	1.646	17°	197°	22°	112°	S	X
EX-NV	Eureka, Nevada	230	39°12'32" N	115°42'37" W	1.951	7°	187°	11°	101°	L	X
MN-NV	Mina, Nevada	234	38°26'10" N	118°08'53" W	1.524	308°	127°	308°	38°	L	X
KM-CL	Kramer, California	275	34°52'52" N	117°15'24" W	0.850	204°	23°	200°	290°	L	X
KN-UT	Kanab, Utah	286	37°01'22" N	112°49'38" W	1.737	92°	274°	95°	185°	L	X
CP-CL	Campo, California	491	32°43'44" N	116°22'16" W	1.189	184°	3°	182°	272°	L	X
TPSO Z1	Tonto Forest Observatory, Arizona	536	34°17'12" N	111°16'03" W	1.492	125°	308°	90°	0°	JM	X
BX-UT	Blanding, Utah	587	37°33'48" N	109°26'05" W	1.707	84°	268°	88°	178°	L	X
UBSO Z10	Uinta Basin Observatory, Utah	664	40°19'18" N	109°34'07" W	1.600	56°	240°	90°	0°	JM	X
DR-CO	Durango, Colorado	732	37°27'53" N	107°47'00" W	2.225	85°	270°	107°	197°	L	X
HL-ID	Hailay, Idaho	737	43°38'50" N	111°15'02" W	1.890	11°	192°	14°	104°	L	X
PI-WY	Cinnadala, Wyoming	809	42°27'10" N	109°32'55" W	2.170	41°	225°	46°	136°	S	-
PHSO Z3	Blue Mountain Observatory, Oregon	862	44°50'56" N	117°18'20" W	1.189	353°	172°	0°	90°	JM	X
LC-NM	Las Cruces, New Mexico	1011	32°24'08" N	106°35'58" W	1.585	119°	304°	124°	214°	L	LPZ-LPR
RT-NM	Raton, New Mexico	1041	36°43'16" N	104°21'37" W	1.951	82°	276°	96°	186°	S	X
PR-MT	Petersburg, Montana	1275	46°06'00" N	106°26'25" W	0.820	36°	222°	43°	133°	S	X
AZ-TX	Amarillo, Texas	1281	35°25'48" N	101°55'50" W	0.988	94°	283°	103°	193°	L	X
TK-WA	Tonasket, Washington	1326	48°47'38" N	119°35'16" W	0.549	349°	166°	347°	77°	L	X
SK-TX	Shamrock, Texas	1428	35°04'58" N	100°21'50" W	0.671	95°	284°	104°	194°	L	X
GI-MT	Glandiva, Montana	1480	47°11'34" N	104°13'10" W	0.732	37°	225°	46°	136°	S	X
MMSO Z6	Wichita Mountain Observatory, Oklahoma	1595	34°43'05" N	98°35'21" W	0.505	95°	285°	90°	0°	JM	X
RY-ND	Rydar, North Dakota	1699	48°05'50" N	101°29'40" W	0.640	40°	230°	50°	140°	S	X
GV-TX	Grapevine, Texas	1798	32°53'09" N	96°59'54" W	0.150	100°	291°	111°	201°	L	LPZ
DU-OK	Durant, Oklahoma	1826	34°02'11" N	96°13'04" W	0.260	95°	287°	107°	197°	L	X
HH-ND	Hannah, North Dakota	1920	48°56'53" N	98°41'33" W	0.488	41°	28°	54°	144°	S	X
HE-TX	Hempstead, Texas	1999	30°11'59" N	96°05'31" W	0.070	107°	298°	116°	208°	L	-
ZB-MT	East Brainerd, Manitoba, Canada	2147	49°37'40" N	95°37'20" W	0.312	43°	237°	58°	148°	S	X
JE-LA	Jana, Louisiana	2279	31°47'05" N	92°00'55" W	0.050	98°	292°	112°	202°	L	X
RK-ON	Red Lake, Ontario, Canada	2337	50°50'20" N	93°40'20" W	0.472	42°	239°	58°	148°	S	X
EU-AL	Eutaw, Alabama	2607	32°47'10" N	87°52'00" W	0.050	92°	289°	109°	199°	S	X
CPSO Z8	Cumberland Plateau Observatory, Tennessee	2728	35°35'42" N	85°34'13" W	0.574	84°	283°	90°	0°	JM	X
BL-WV	Beckley, West Virginia	3056	37°47'56" N	81°18'36" W	0.610	78°	279°	100°	190°	S	X
BR-PA	Berlin, Pennsylvania	3235	39°55'27" N	78°50'41" W	0.664	73°	277°	97°	187°	L	X
DH-NY	Delhi, New York	3541	42°14'39" N	74°53'18" W	0.652	68°	275°	95°	185°	S	X
LL-NH	Lisbon, New Hampshire	3756	44°14'18" N	71°55'21" W	0.287	64°	273°	110°	200°	S	X
HN-ME	Houlton, Maine	4062	46°09'43" N	67°59'09" W	0.210	60°	273°	93°	183°	S	X
HW-IS	Kauai, Hawaii	4280	19°58'49" N	155°42'20" W	0.705	255°	55°	235°	325°	L	X
NP-NT	Mould Bay, Northwest Territories, Canada	4362	76°15'08" N	119°22'18" W	0.059	359°	176°	356°	86°	JNZ-ZBN	X
GM-CU	Guantanamo, Cuba	4391	19°58'01" N	75°05'14" W	0.016	104°	305°	125°	215°	S	X
PZ-PR	Ponce, Puerto Rico	5269	17°58'12" N	66°25'04" W	0.005	100°	324°	124°	214°	S	X
LZ-BV	La Paz, Bolivia	7725	16°15'31" S	68°28'47" W	3.993	131°	321°	141°	231°	JMZ-LBR	X
OO-NW	Oslo, Norway	8120	61°03'17" N	10°51'58" E	0.555	24°	318°	138°	228°	L	X
SB-DE	G. fenberg, Germany	9093	49°41'32" N	11°12'55" E	0.530	31°	320°	140°	230°	L	X

Recording Site Information - KLICKITAT  
Appendix I(A)

Unified Magnitude:  $m = \log_{10} (A/T) + B$

where

A = zero to peak ground motion in millimicrons

$$= \frac{(mm)(1000)}{K}$$

K

T = signal period in seconds

B = distance factor (see Table below)

mm = record amplitude in millimeters zero to peak

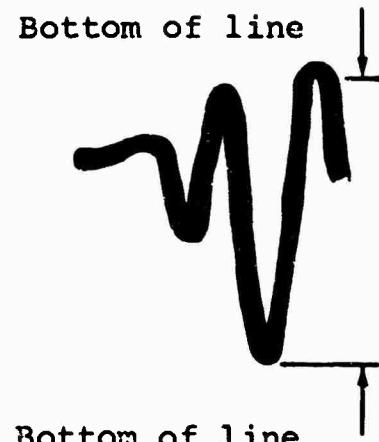
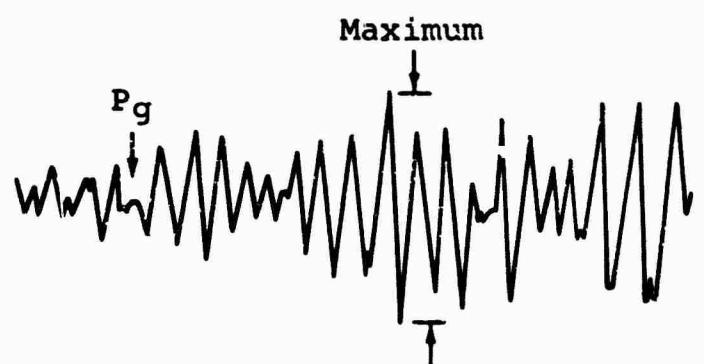
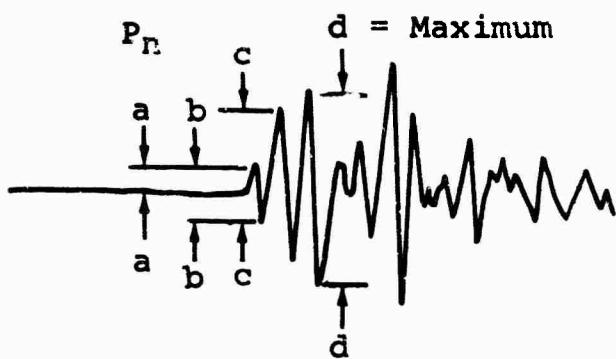
K = magnification in thousands at signal frequency

Table of Distance Factors (B) for Zero Depth

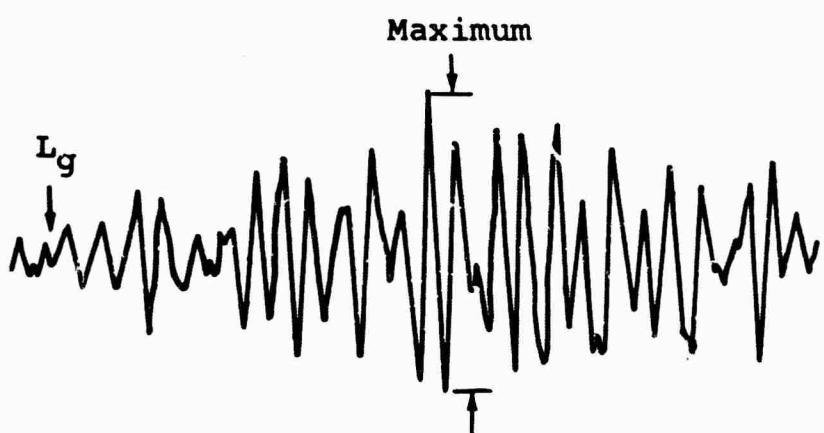
Dist (deg)	B	Dist (deg)	B	Dist (deg)	B	Dist (deg)	B
0°	-	27°	3.5	54°	3.8	80°	3.7
1	-	28	3.6	55	3.8	81	3.8
2	2.2	29	3.6	56	3.8	82	3.9
3	2.7	30	3.6	57	3.8	83	4.0
4	3.1	31	3.7	58	3.8	84	4.0
5	3.4	32	3.7	59	3.8	85	4.0
6	3.6	33	3.7	60	3.8	86	3.9
7	3.8	34	3.7	61	3.9	87	4.0
8	4.0	35	3.7	62	4.0	88	4.1
9	4.2	36	3.6	63	3.9	89	4.0
10	4.3	37	3.5	64	4.0	90	4.0
11	4.2	38	3.5	65	4.0	91	4.1
12	4.1	39	3.4	66	4.0	92	4.1
13	4.0	40	3.4	67	4.0	93	4.2
14	3.6	41	3.5	68	4.0	94	4.1
15	3.3	42	3.5	69	4.0	95	4.2
16	2.9	43	3.5	70	3.9	96	4.3
17	2.9	44	3.5	71	3.9	97	4.4
18	2.9	45	3.7	72	3.9	98	4.5
19	3.0	46	3.8	73	3.9	99	4.5
20	3.0	47	3.9	74	3.8	100	4.4
21	3.1	48	3.9	75	3.8	101	4.3
22	3.2	49	3.8	76	3.9	102	4.4
23	3.3	50	3.7	77	3.9	103	4.5
24	3.3	51	3.7	78	3.9	104	4.6
25	3.5	52	3.7	79	3.8	105	4.7
26	3.4	53	3.7				

Unified Magnitudes From P<sub>n</sub> or P Waves

Appendix I(B)



Detail Showing Allowance  
For Line Width



Pick time of  $P_n$  at beginning of "a" half cycle.

Pick amplitude of  $P_n$  as maximum " $d/2$ " within 2 or 3 cycles of "c".

Pick amplitudes of  $P_g$  and  $L_g$  at maximum of corresponding motion.

#### Seismic Analysis Diagram

#### Appendix II

FIRST MOTION CRITERIA  
TECHNICAL WORKING GROUP II (TWG II)

Excerpt from Appendices to Hearings before the Special Subcommittee on Radiation and the Subcommittee on Research and Development of the Joint Committee on Atomic Energy; 86th Cong., 2d Sess.; April 19-22, 1960; on Technical Aspects of Detection and Inspection Controls of a Nuclear Weapons Test Ban; Part 2 of 2 Parts, pp 632-633:

"2. Identification of Earthquakes

A located seismic event shall be ineligible for inspection if, and only if, it fulfills one or more of the following criteria:

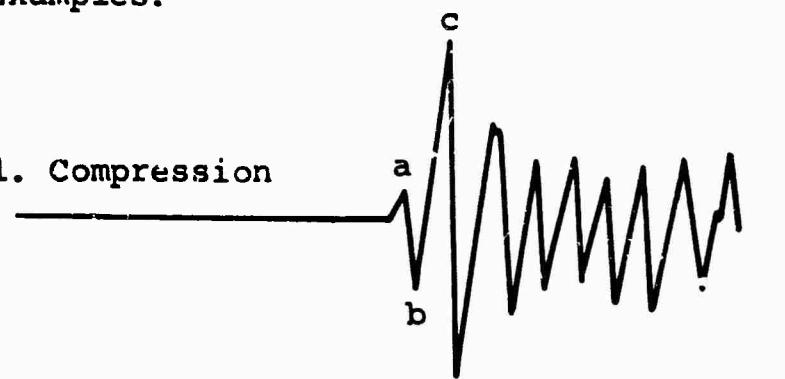
- a. Its depth of focus is established as below 60 kilometers;
- b. Its epicentral location is established to be in the deep open ocean and the event is unaccompanied by a hydroacoustic signal consistent with the seismic epicenter and origin time;
- c. It is established within 48 hours to be a foreshock by the occurrence of a larger event of at least magnitude 6 whose epicenter coincides with that of the given event within the accuracy of the determination of the two epicenters. The eligibility of the second event for inspection must be determined separately.
- d. The directions of clearly recorded first motions define a pattern which strongly indicates a faulting source. First motions recorded at distances between 1100 kilometers and 2500 kilometers will not be used. First motions beyond 3500 kilometers will not be used for events of magnitude smaller than 5.5. The apparent direction of first motion must also meet both the following minimum conditions to be considered to be clearly recorded:
  - (1) The amplitude of the half-cycle of apparent first motion is at least two (2) times as large as any half-cycle of apparent noise in the preceding few minutes, and
  - (2) The largest of the amplitudes of the half-cycle of apparent first motion and the two immediately following half-cycles:
    - (a) at epicentral distances less than 700 kilometers is twenty (20) times larger than any half-cycle of noise in the preceding few minutes;
    - (b) at epicentral distances more than 700 kilometers is forty (40) times larger than any half-cycle of noise in the preceding few minutes.

A pattern of clearly recorded first motions strongly indicates a faulting source if the observed motions, extended backward to a small sphere about the focus, can be separated into alternate quadrants by two orthogonal great circles drawn on the small sphere, with the requirement that two opposite quadrants combined (i) contain at least 4 clearly recorded rarefactive first motions and (ii) contain not more than 15% compressions among the clearly recorded first motions."

## Application of the FWG II Criteria

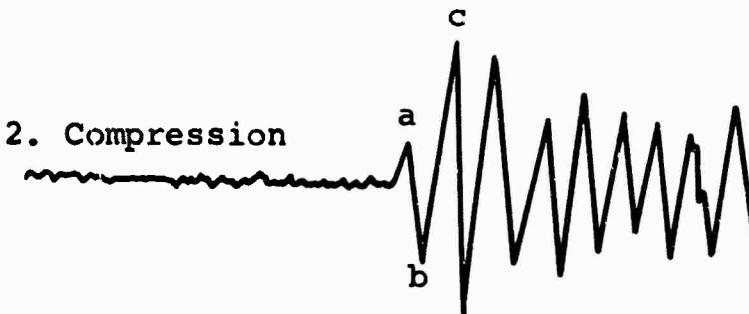
Examples:

1. Compression



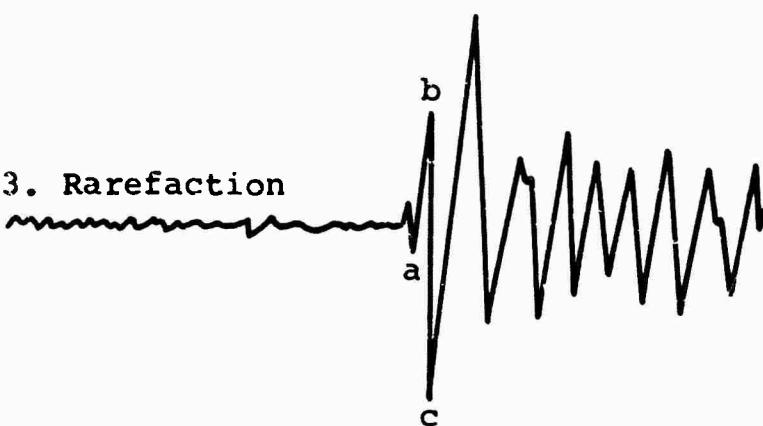
$$700 < \Delta < 1100 \text{ Km}$$

2. Compression



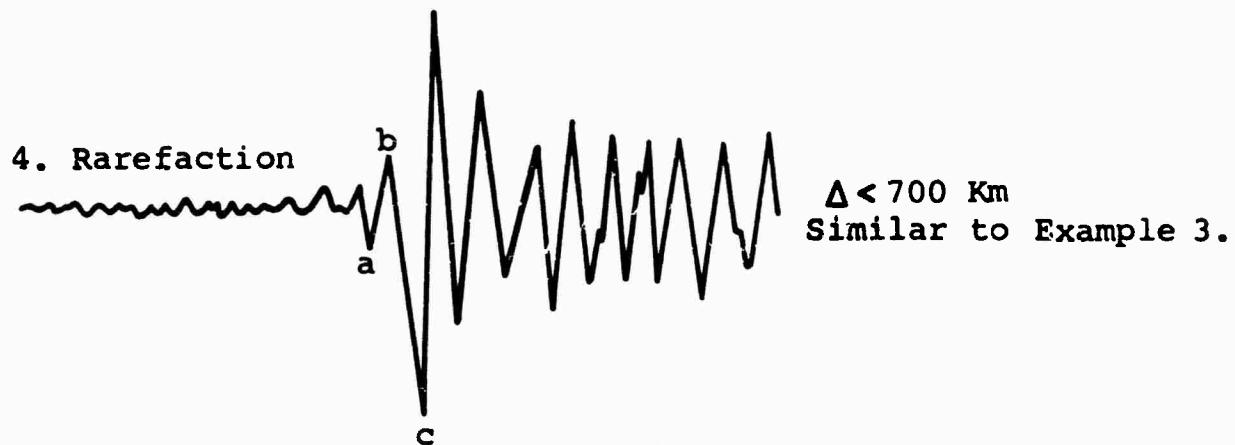
$$\Delta < 700 \text{ Km}$$

3. Rarefaction

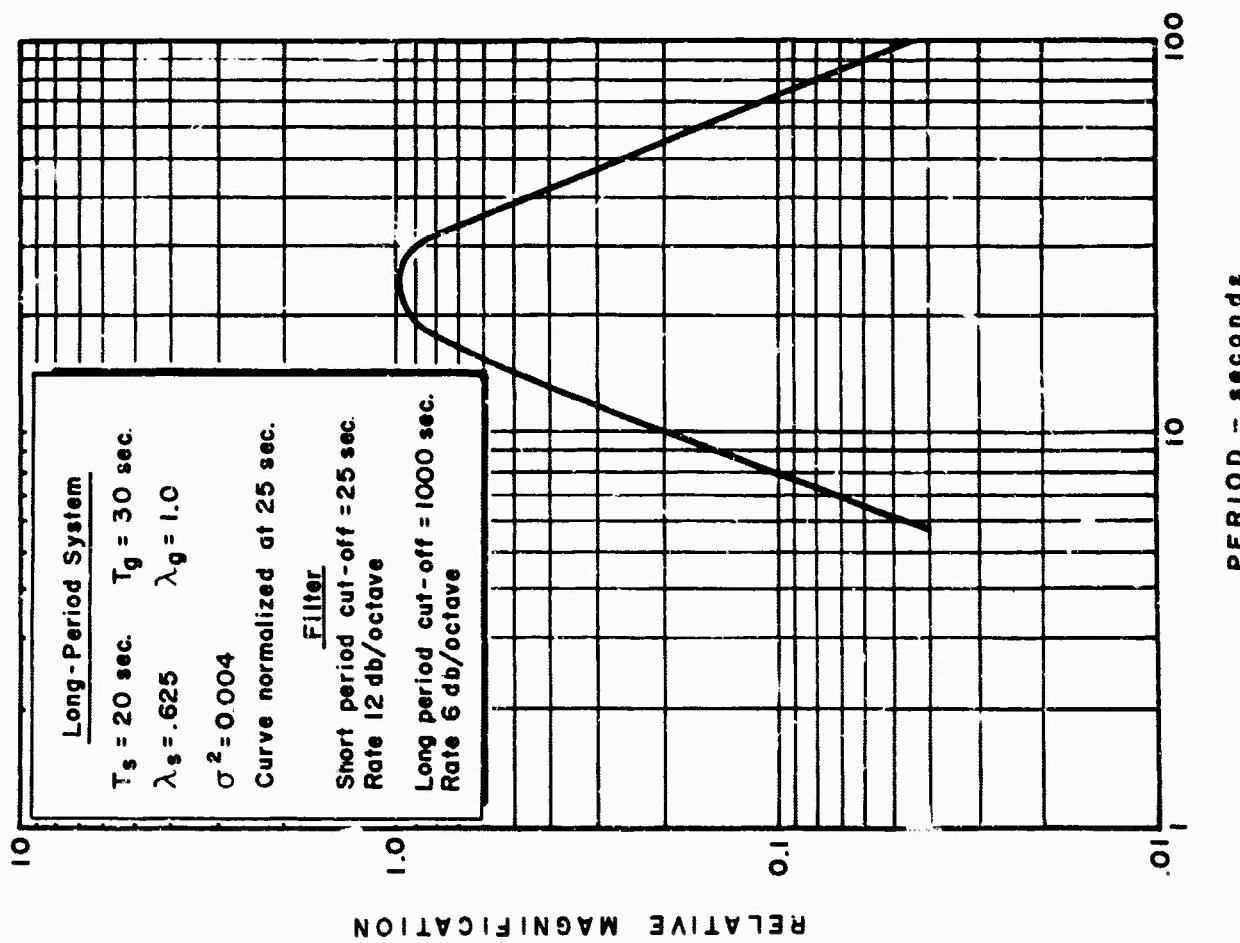
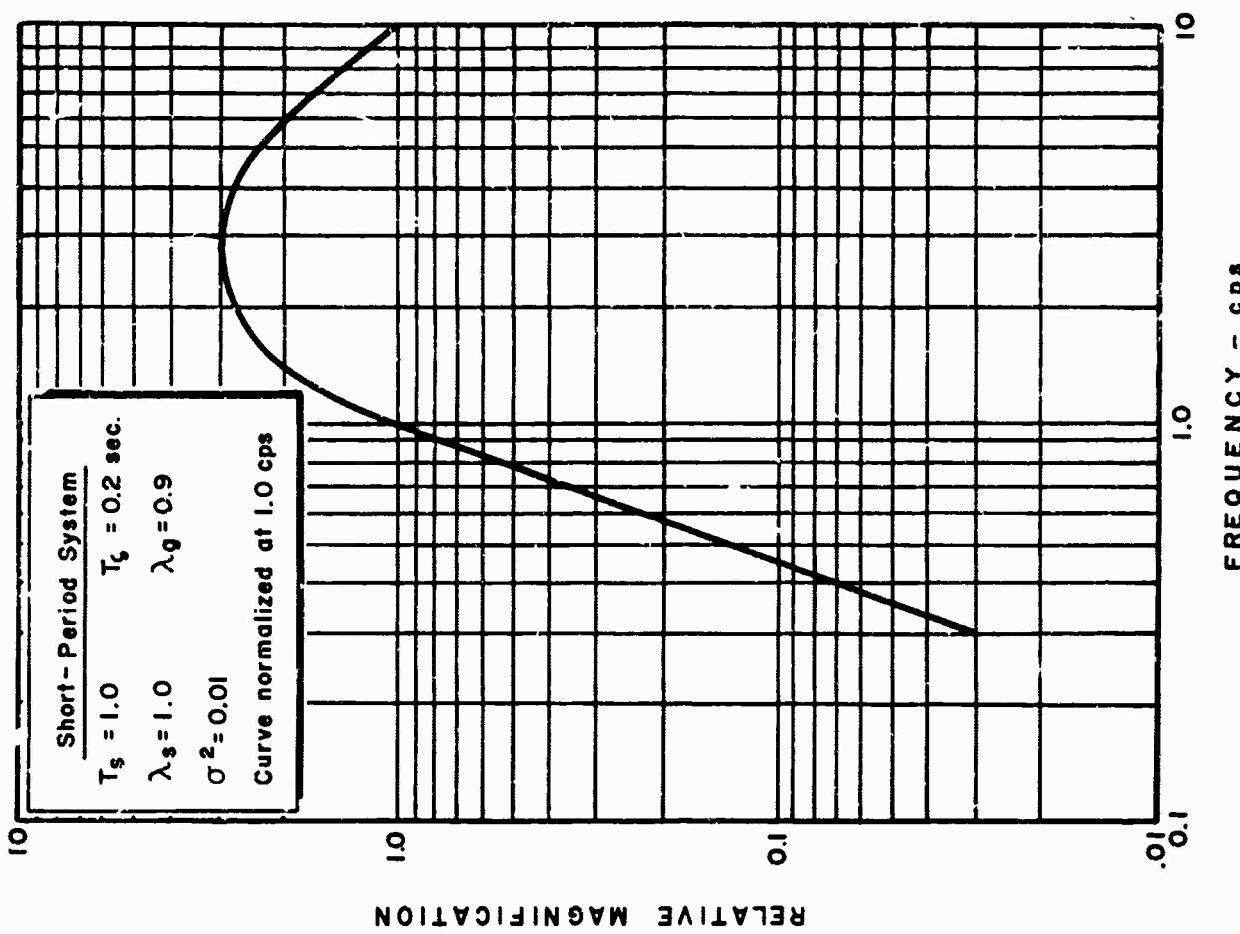


$\Delta < 700 \text{ Km}$ . Example shows what may be interpreted to be earlier signal; however, motion is less than 2 times the noise level and may be interpreted as noise.

## Application of the TWG II Criteria



LP and SP Response Curves



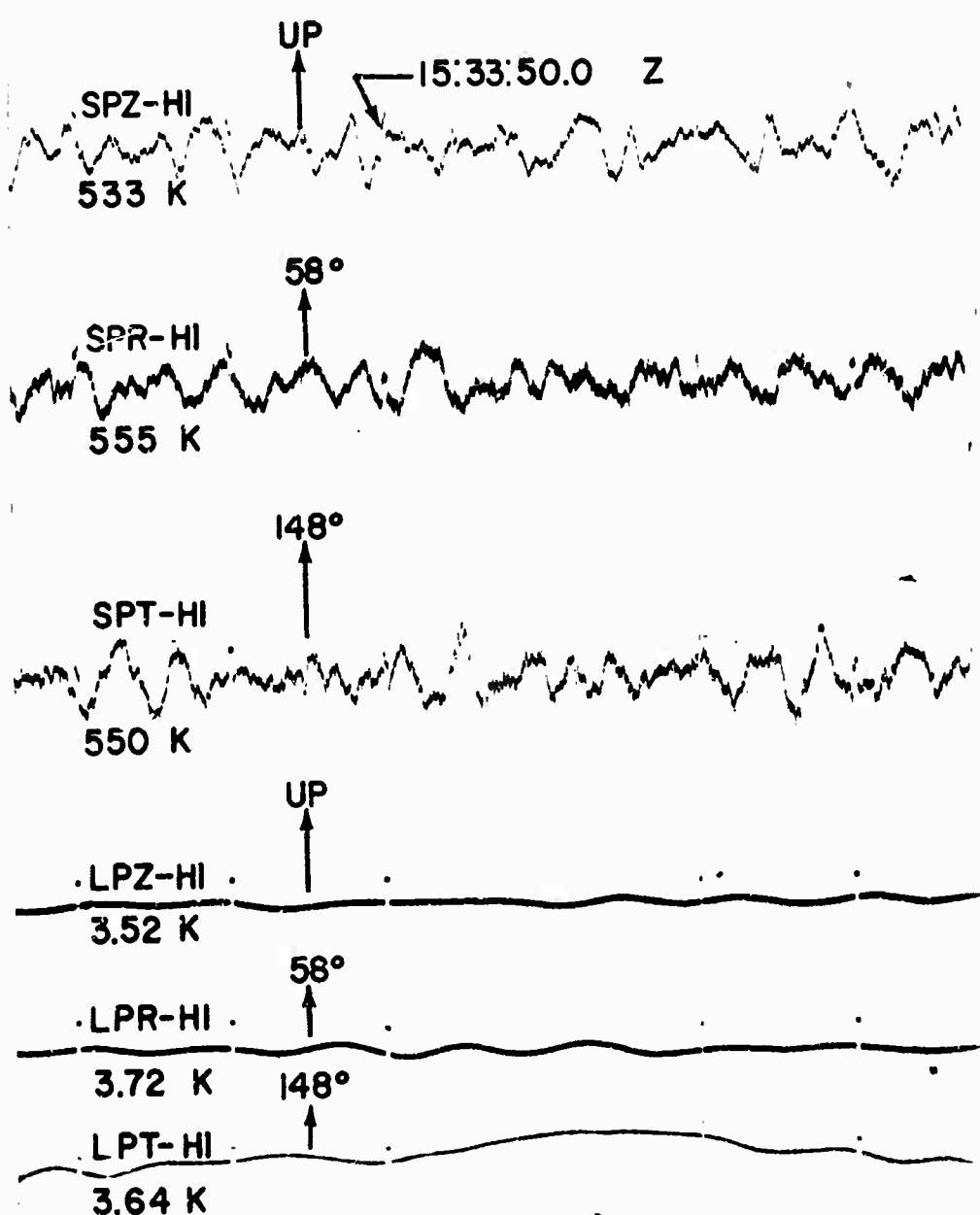
**KLICKITAT**

**EB-MT**

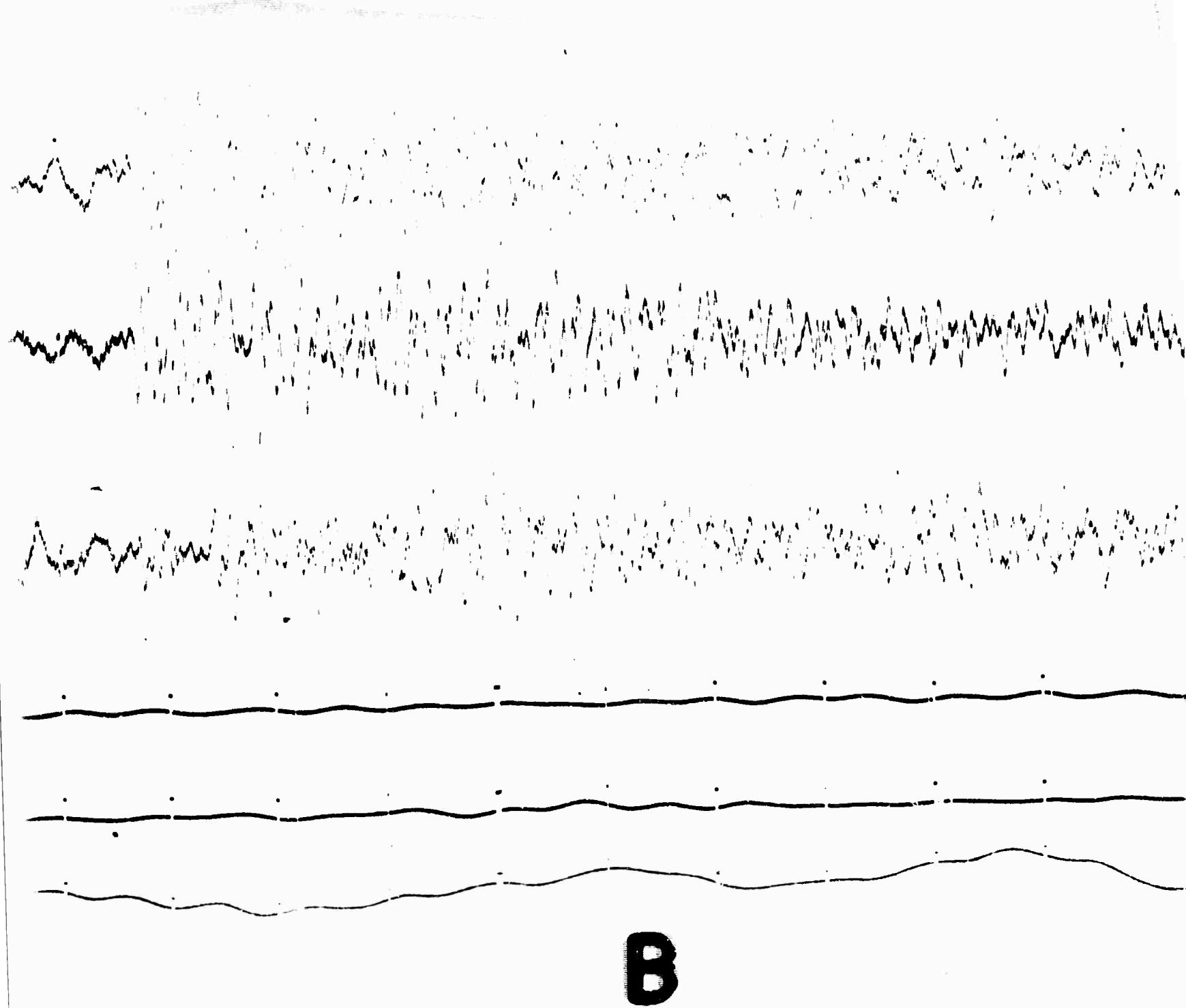
**East Braintree, Manitoba**

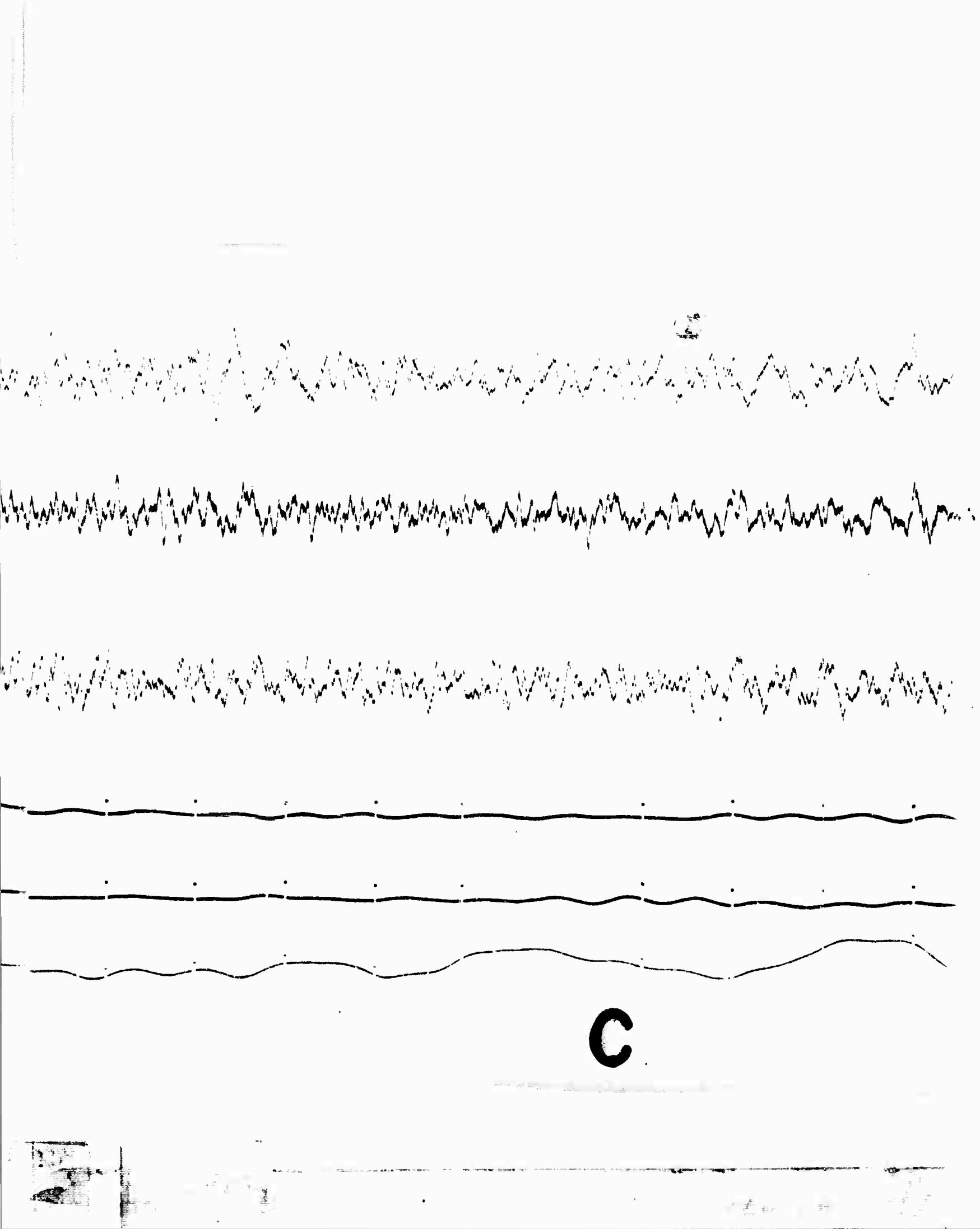
**20 February 1964**

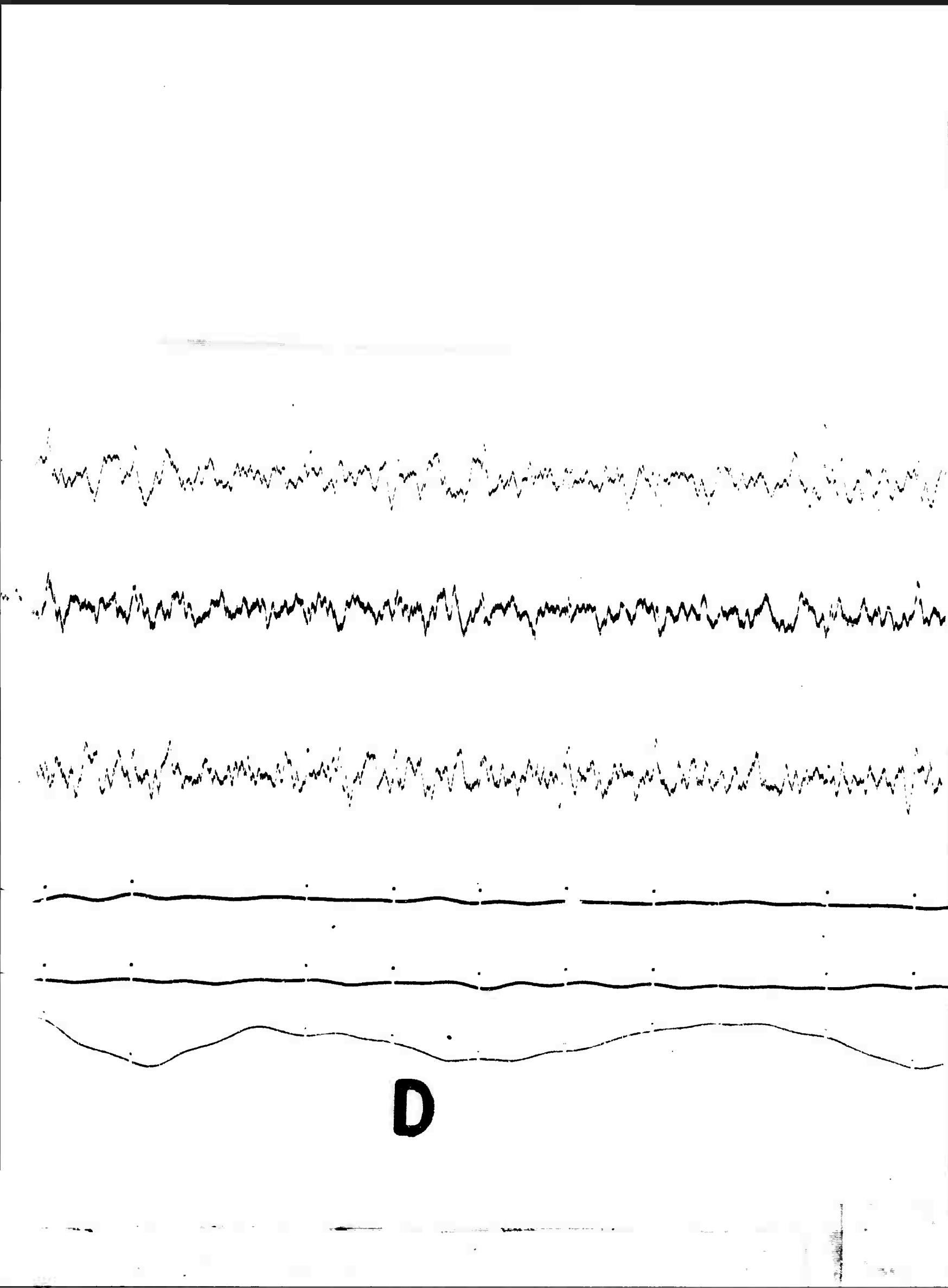
**$\Delta = 2147 \text{ km}$**

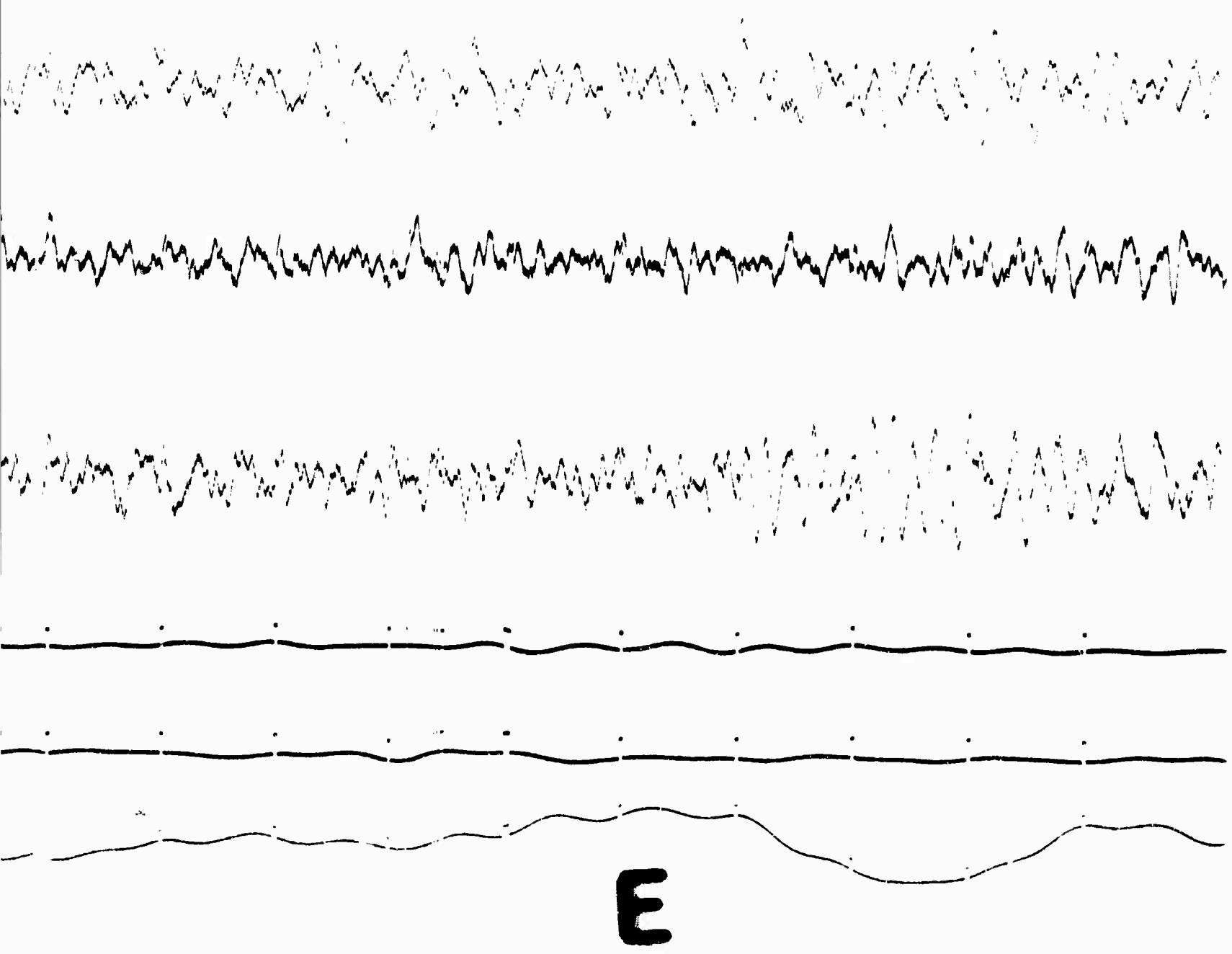


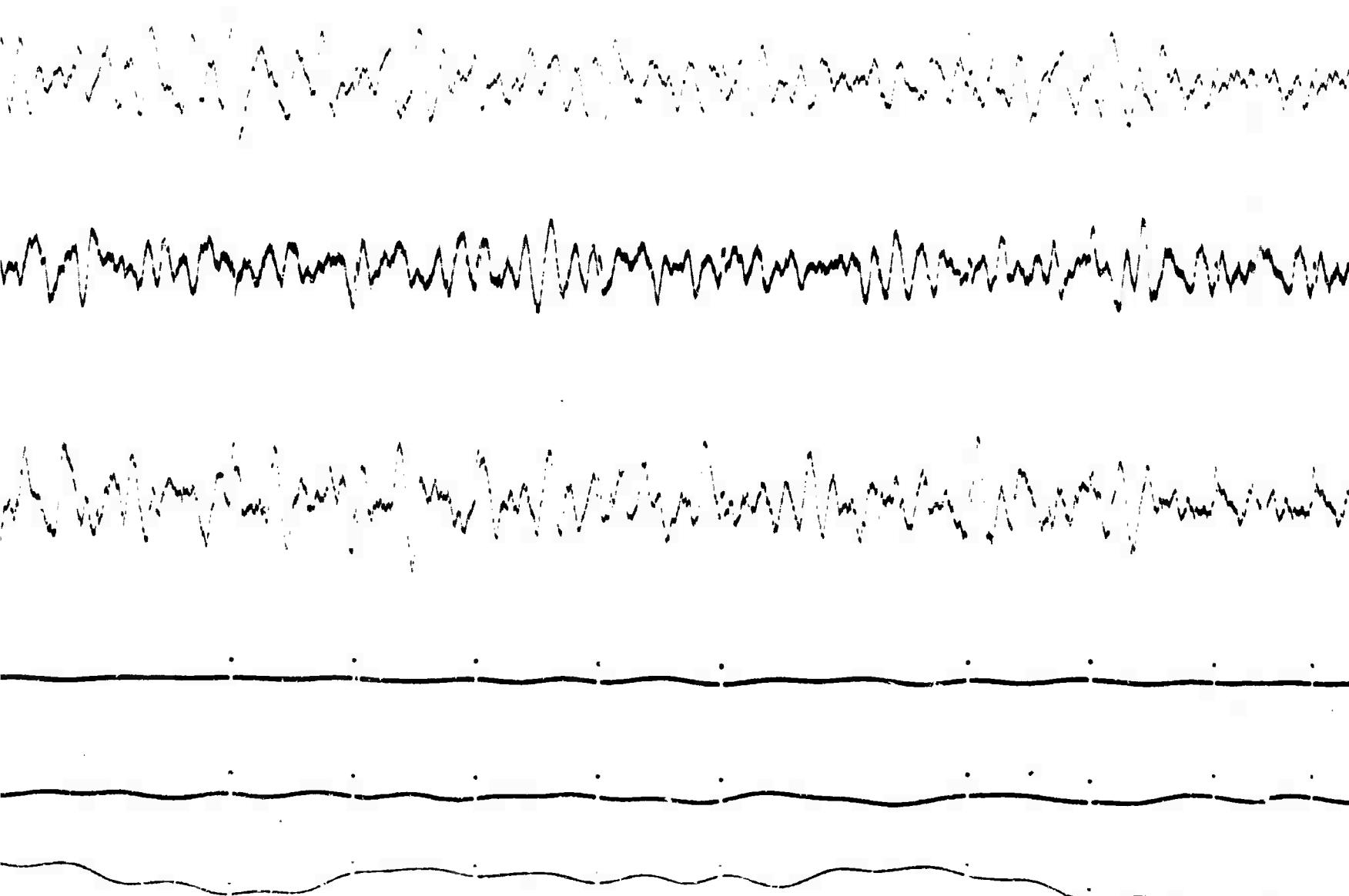
**A**



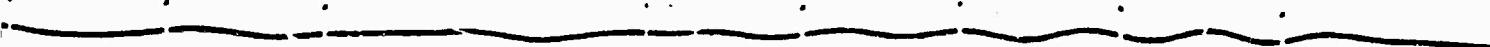
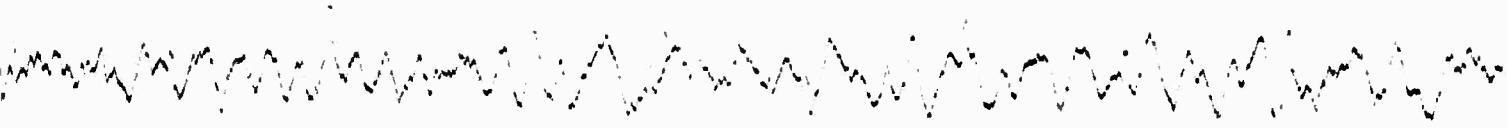








F



6

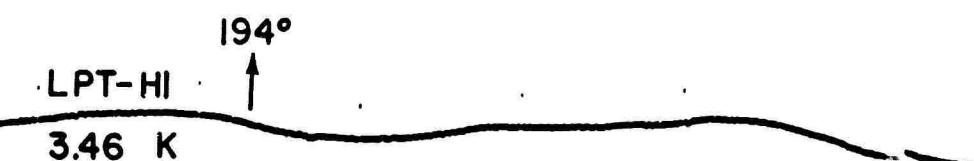
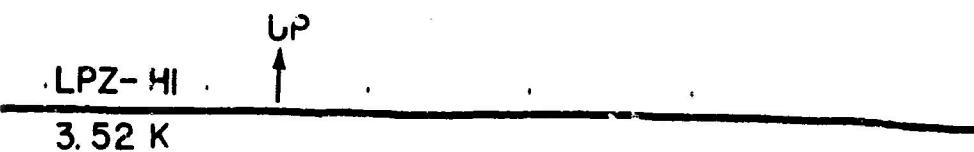
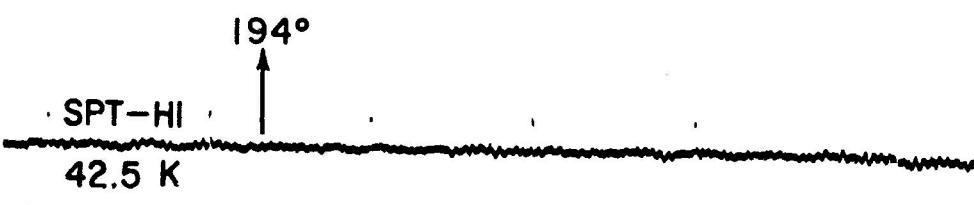
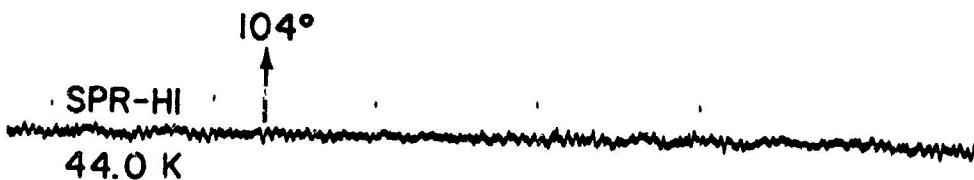
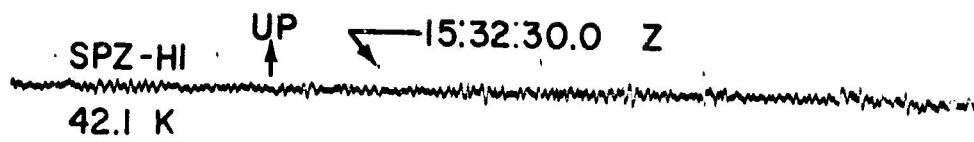
**KLICKITAT**

**SK-TX**

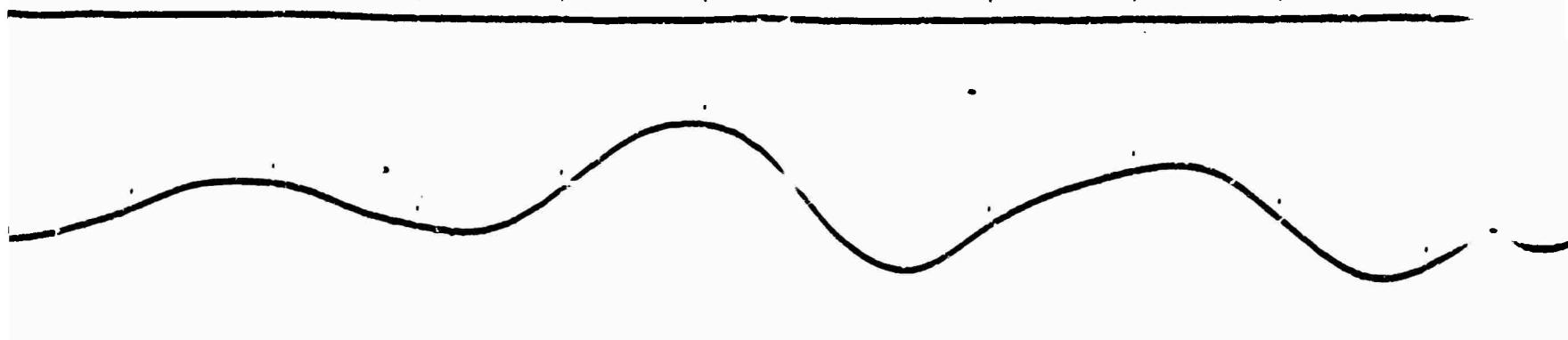
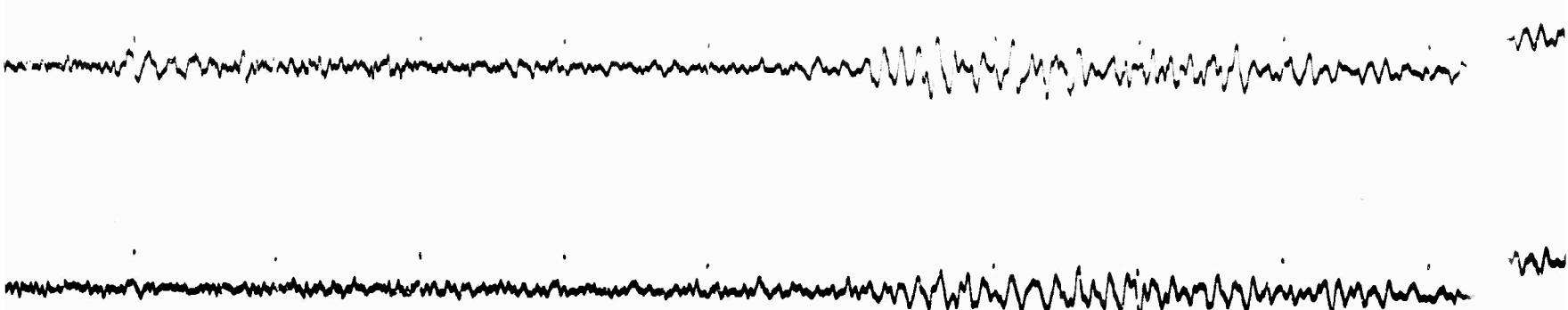
**Shamrock, Texas**

**20 February 1964**

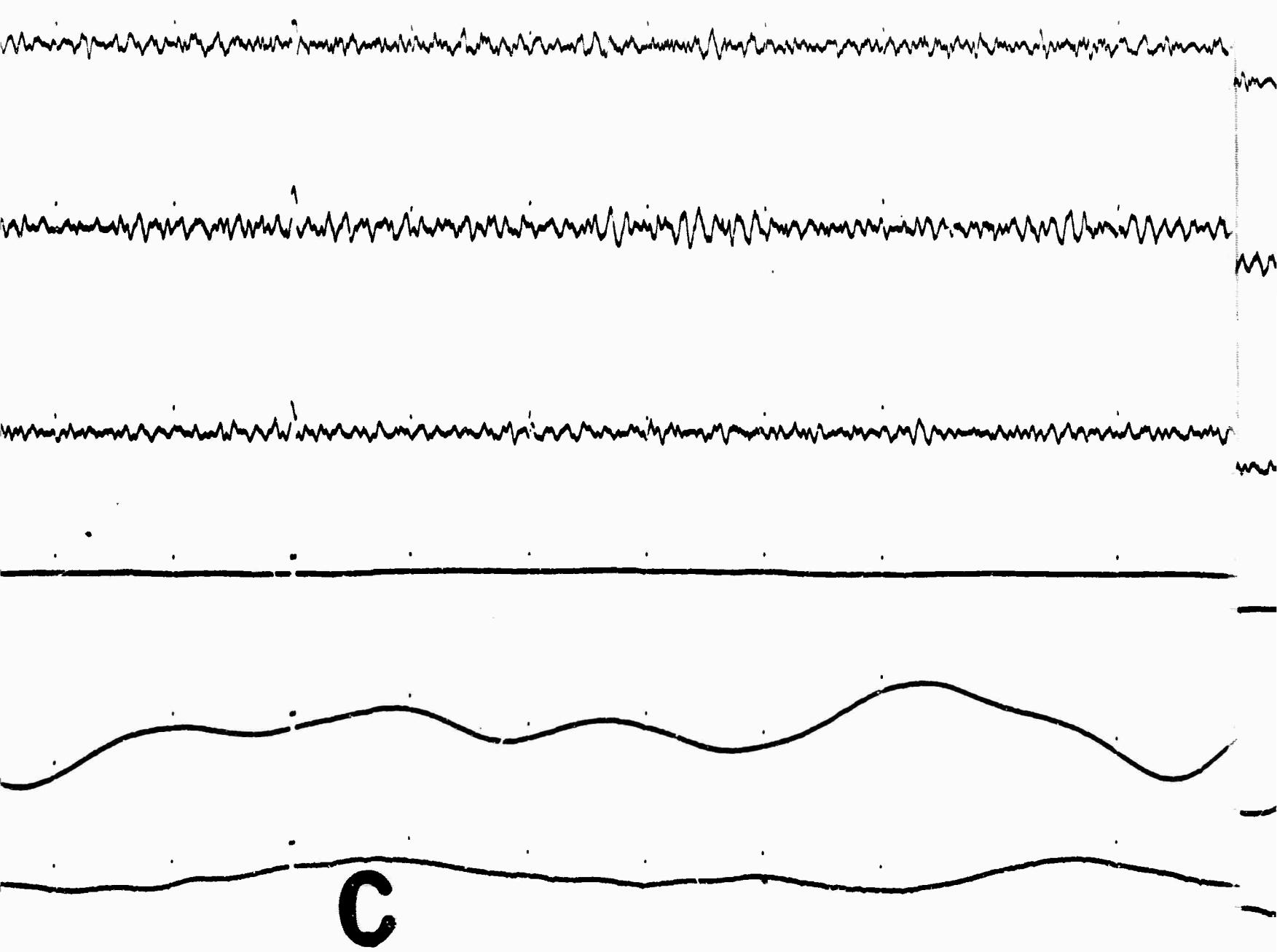
**$\Delta = 1428 \text{ km}$**

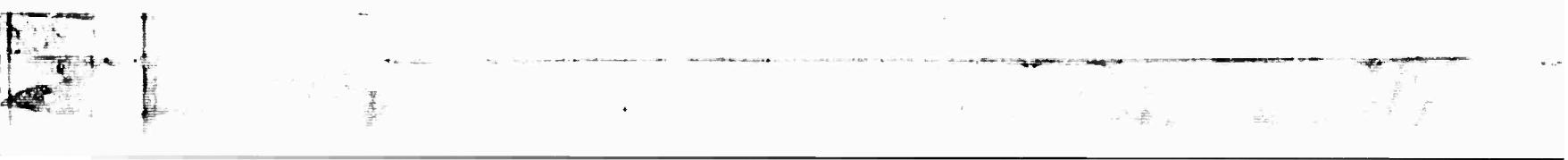
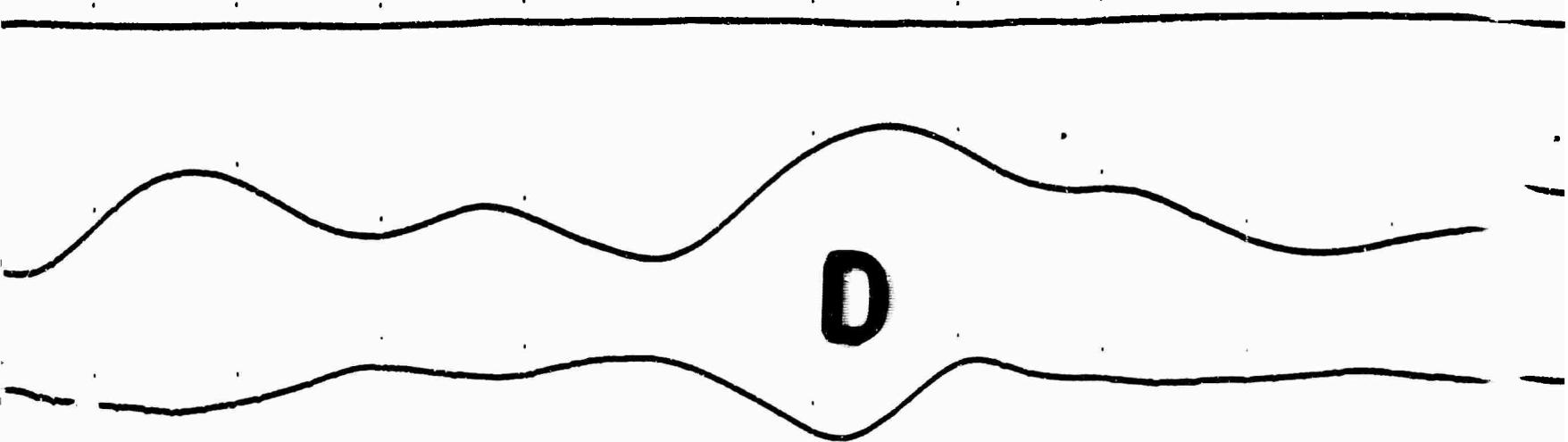
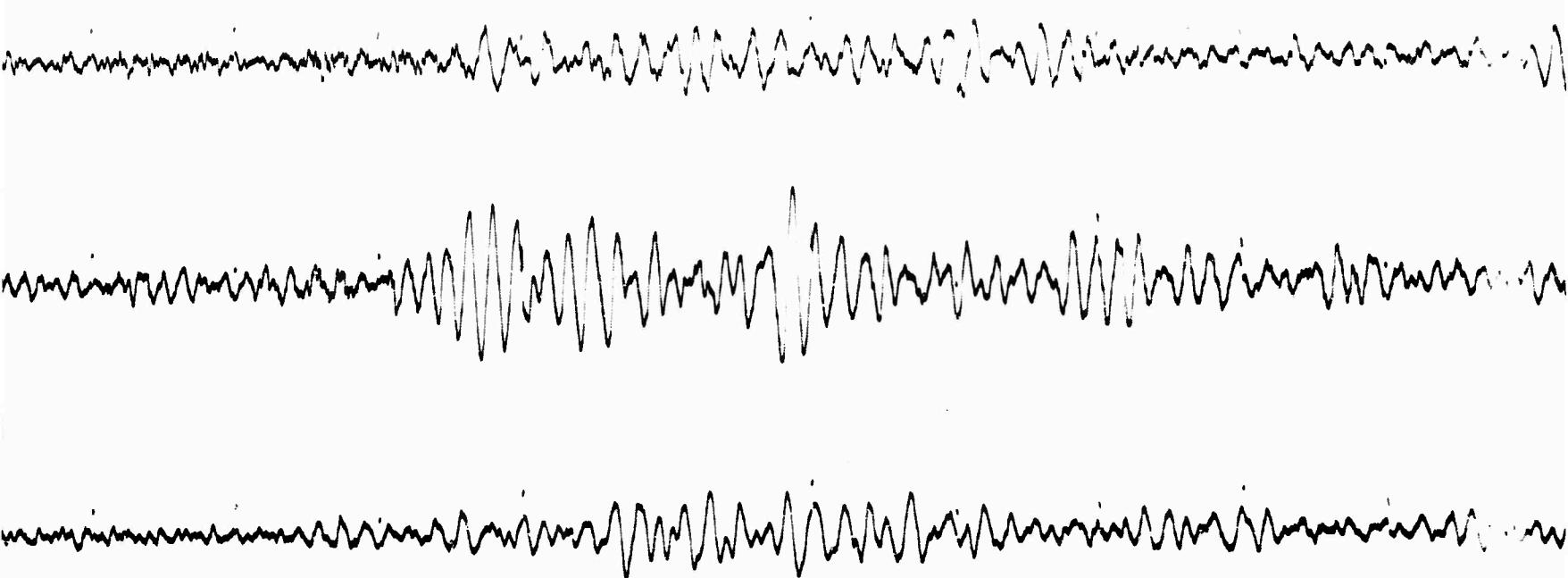


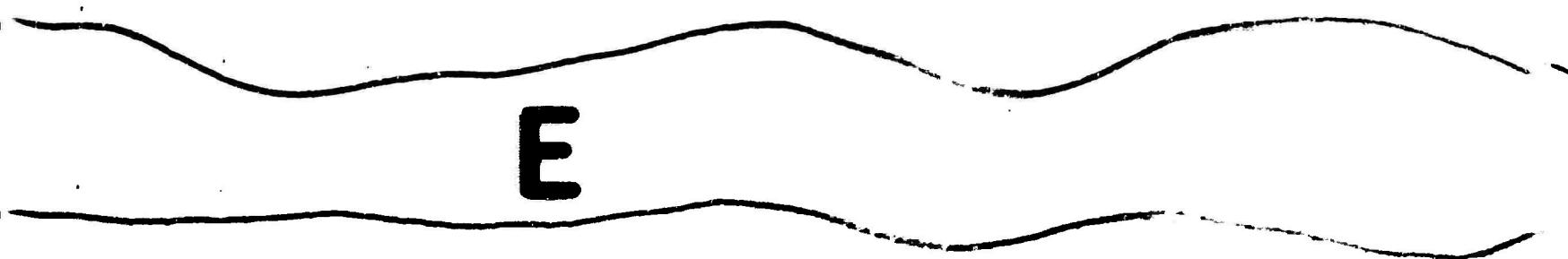
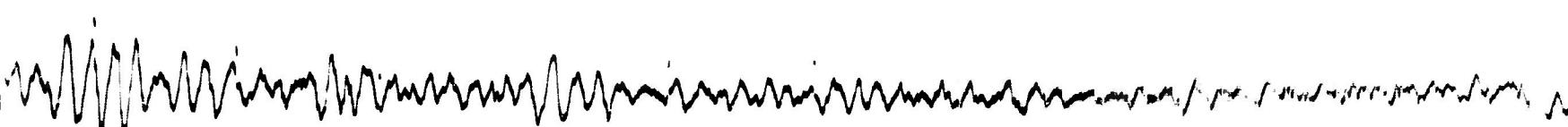
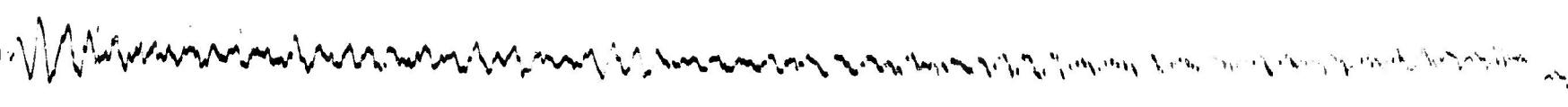
**A**

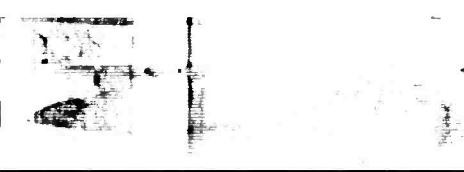
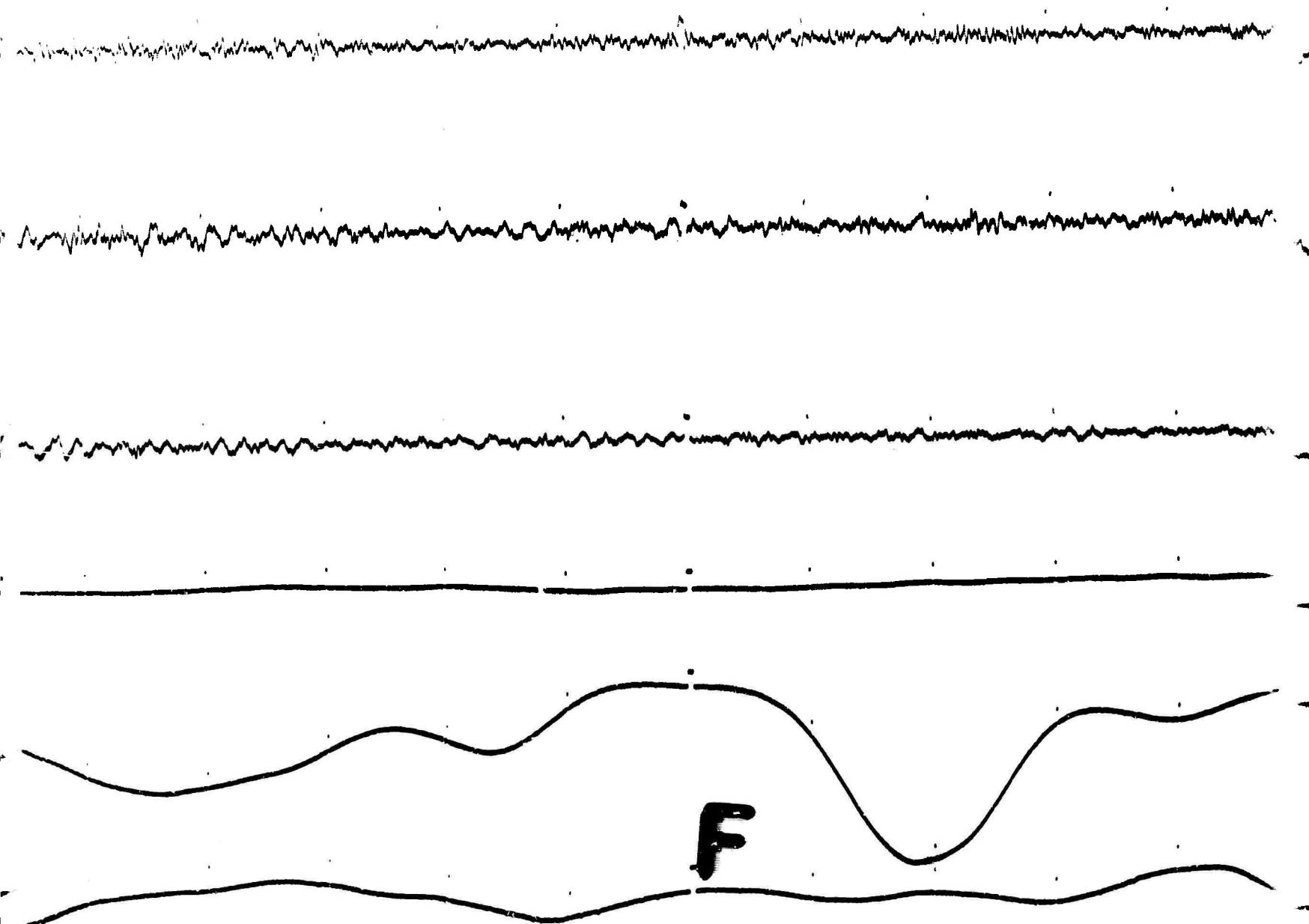


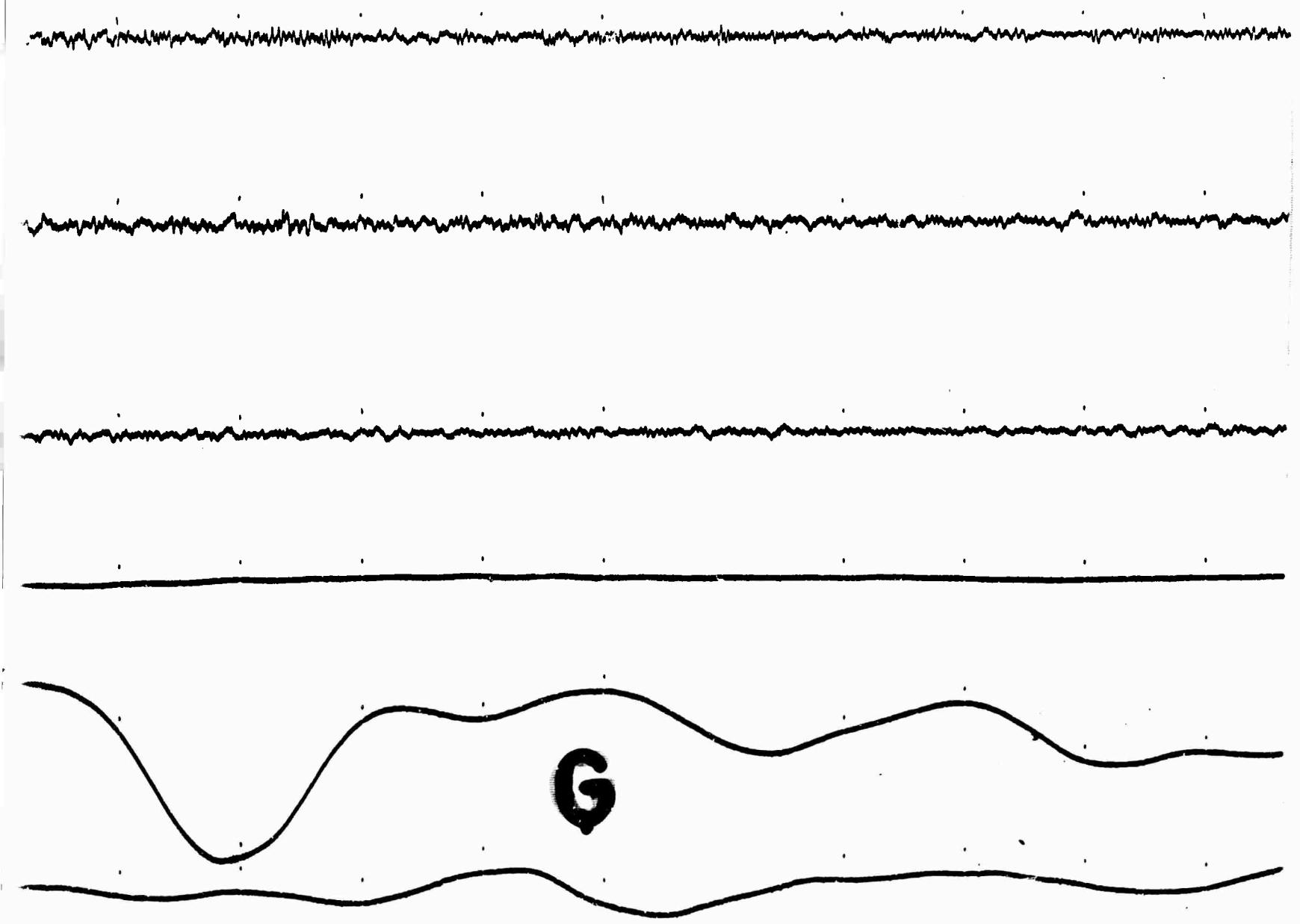
B

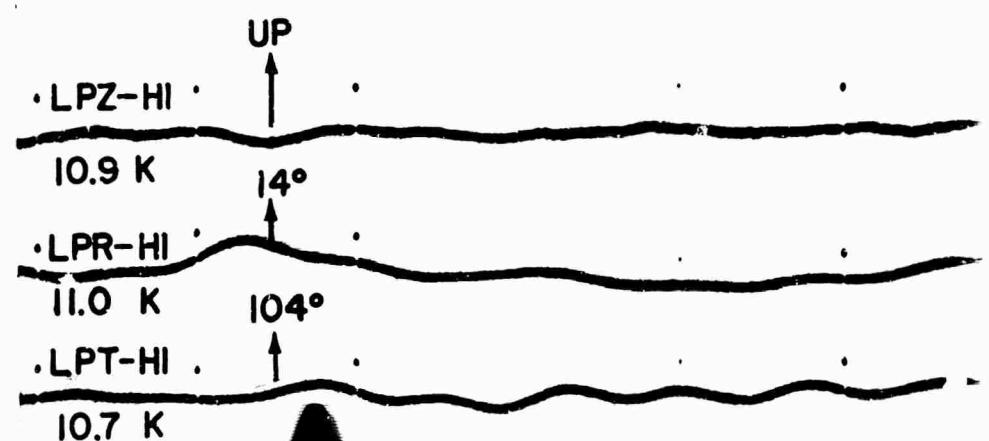
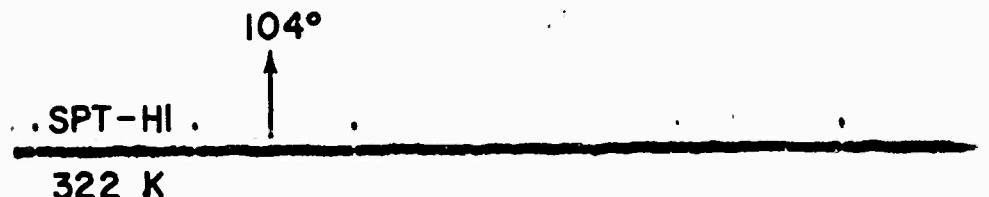
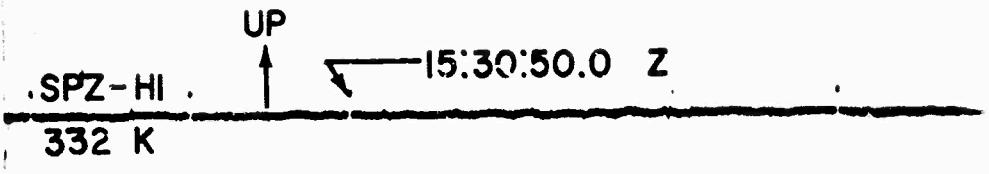












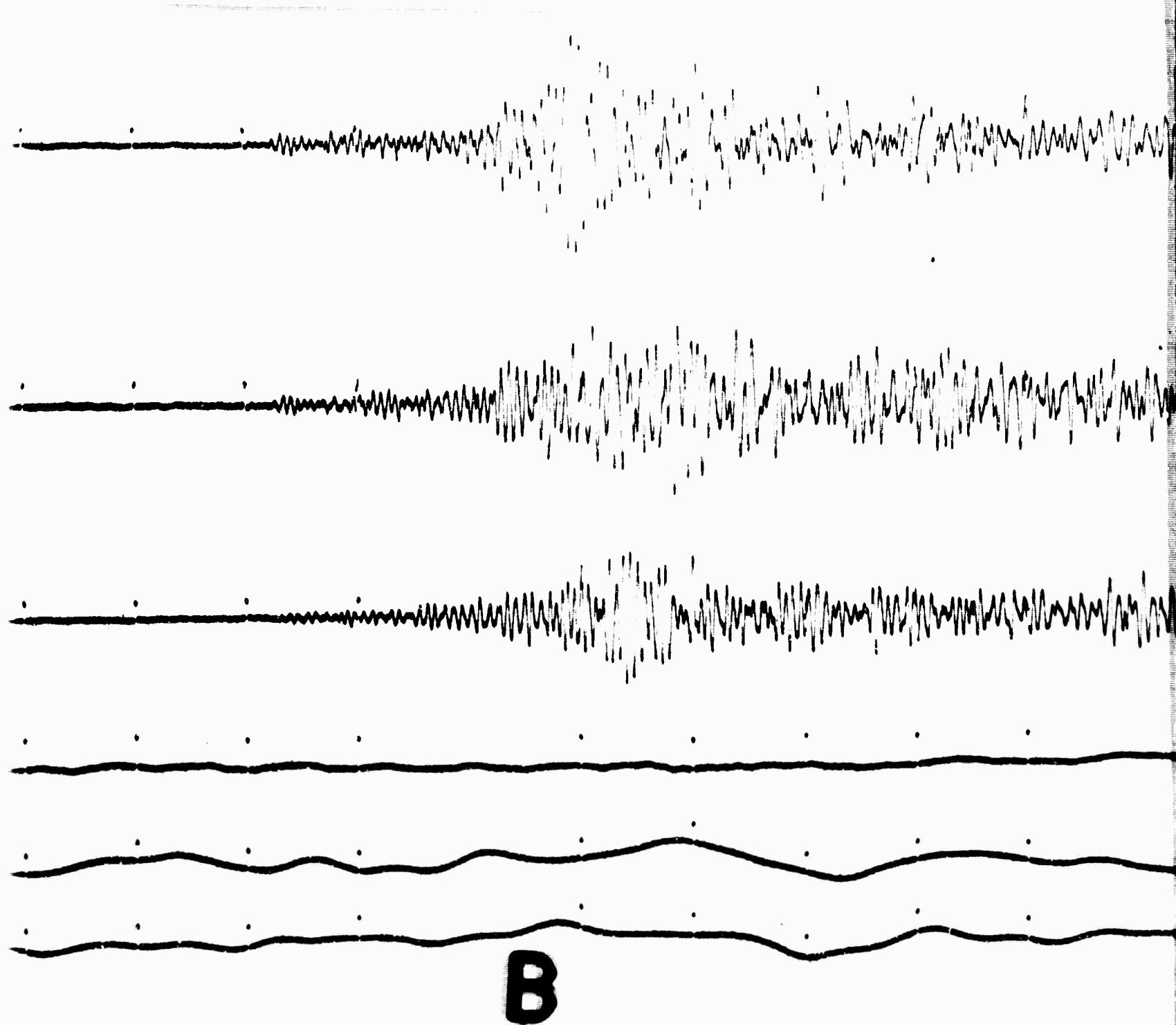
**KLIKKITAT**

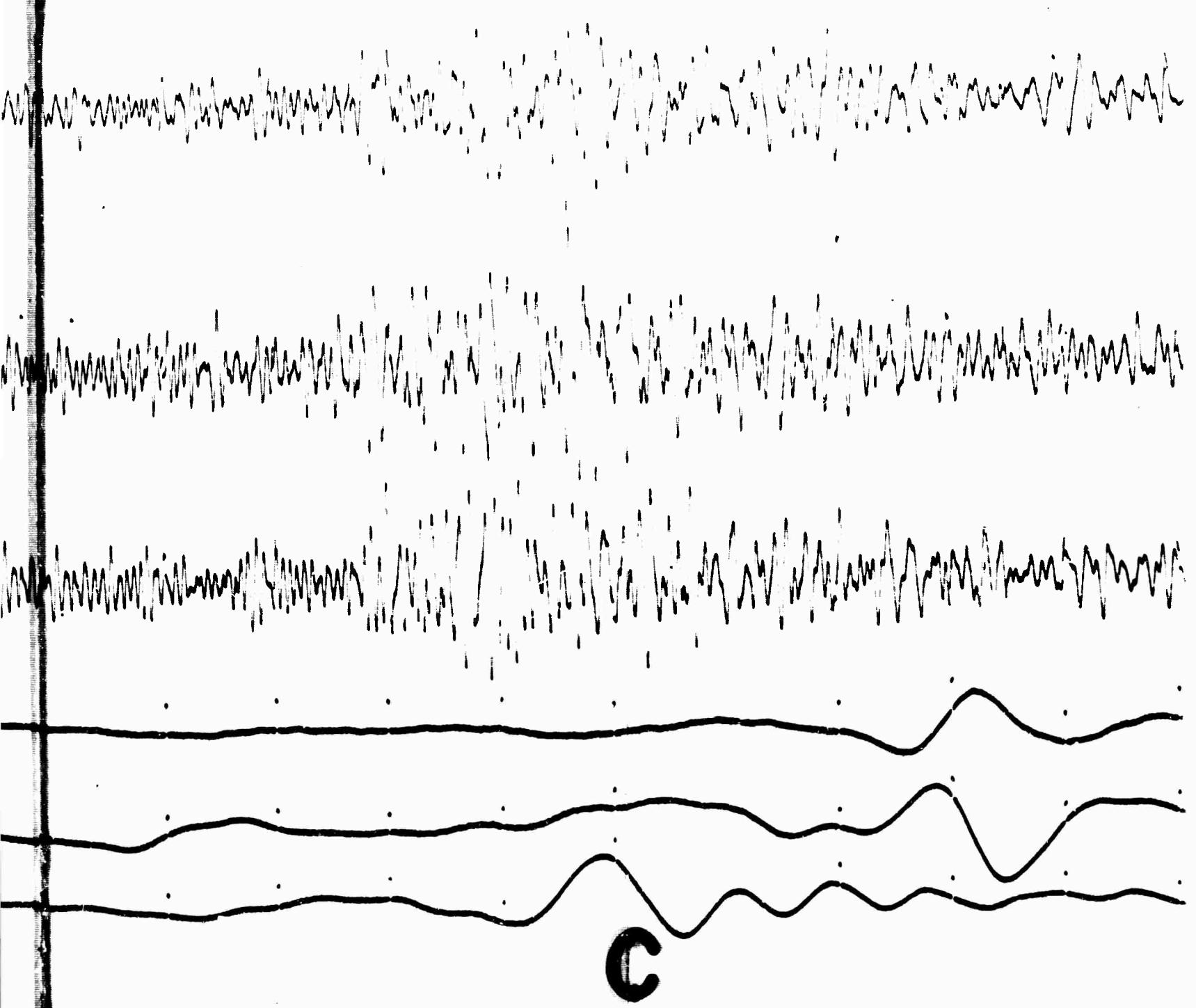
**HL-ID**

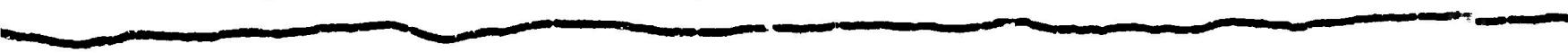
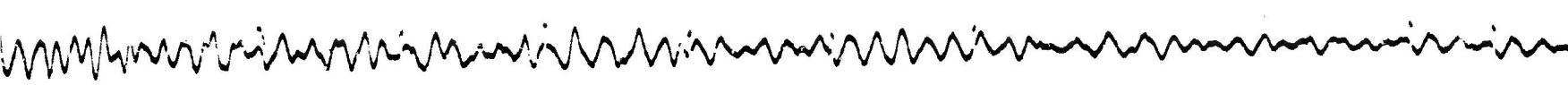
Hailey, Idaho

20 February 1964

$\Delta = 737 \text{ km}$

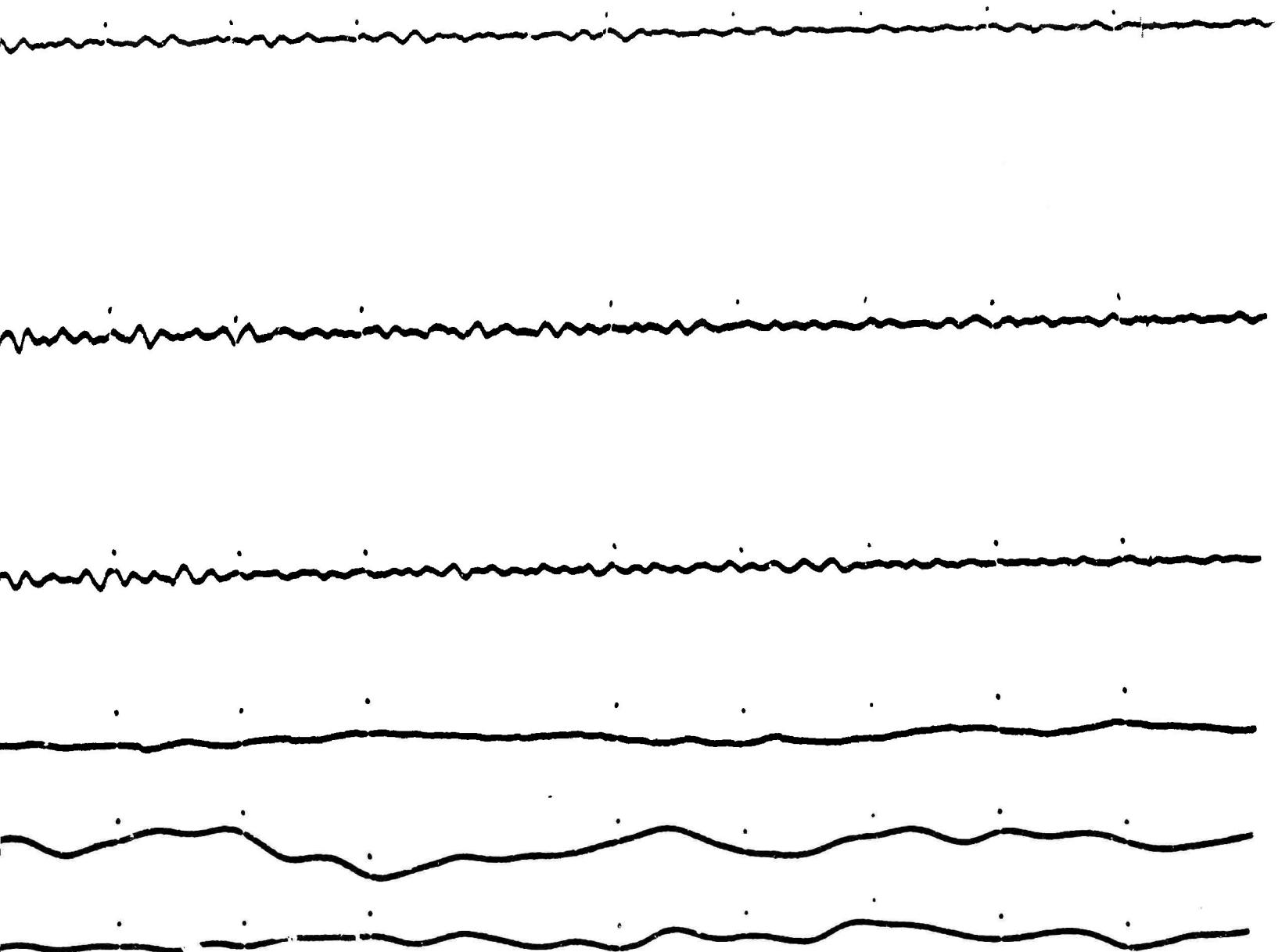






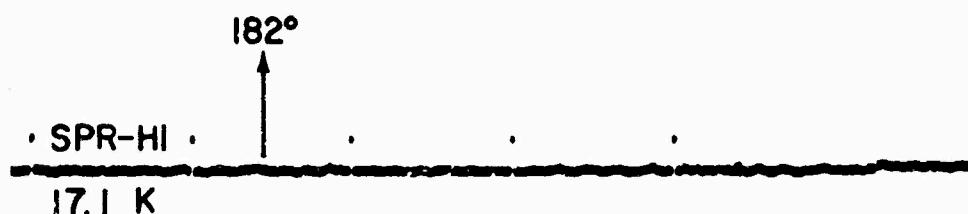
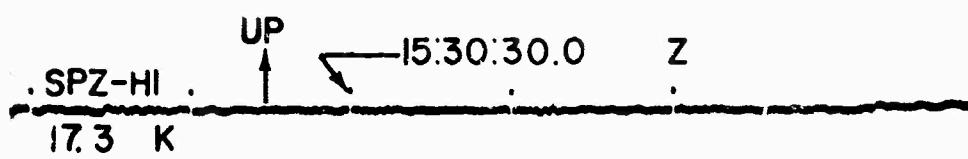
D





E





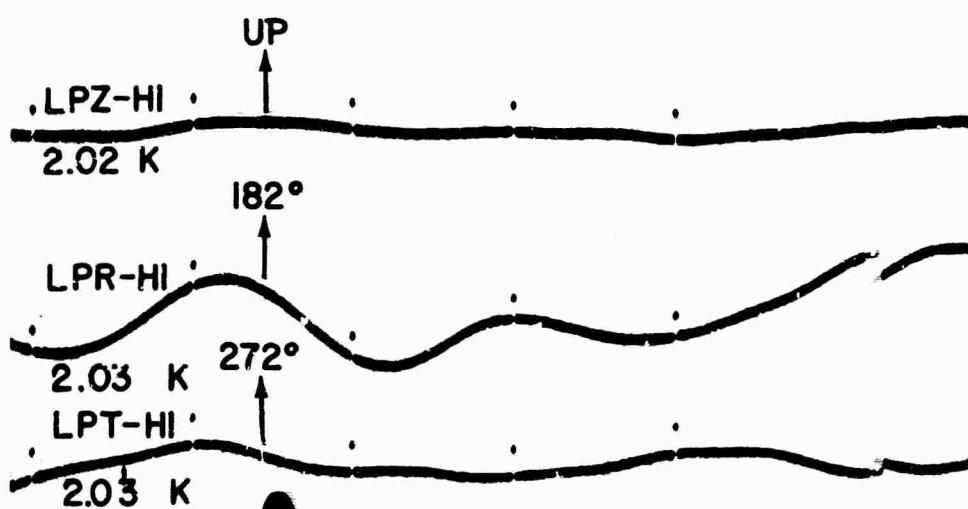
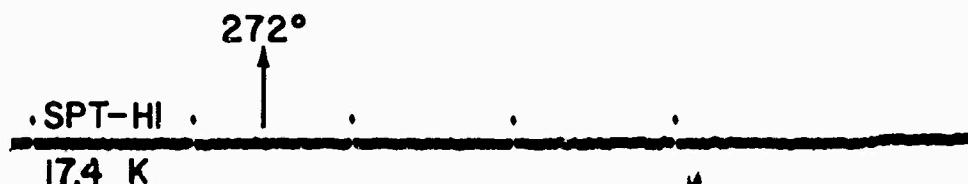
**KLIKKITAT**

**CP-CL**

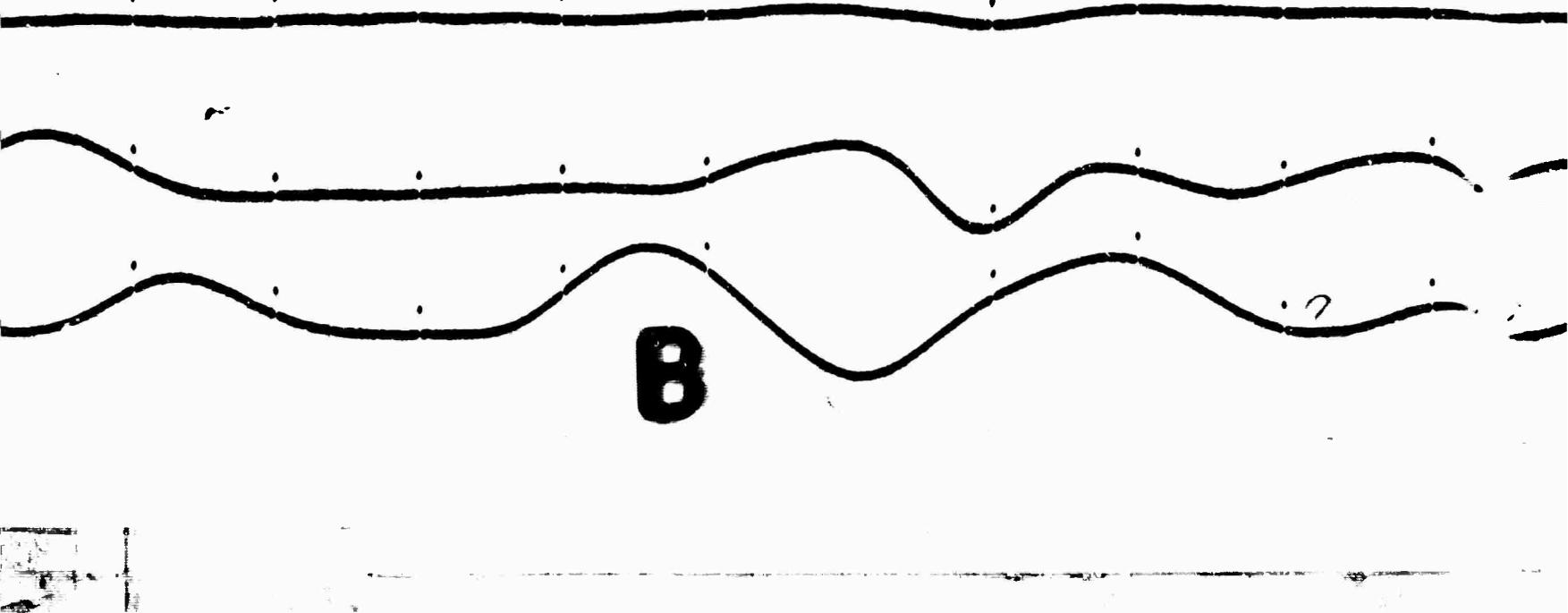
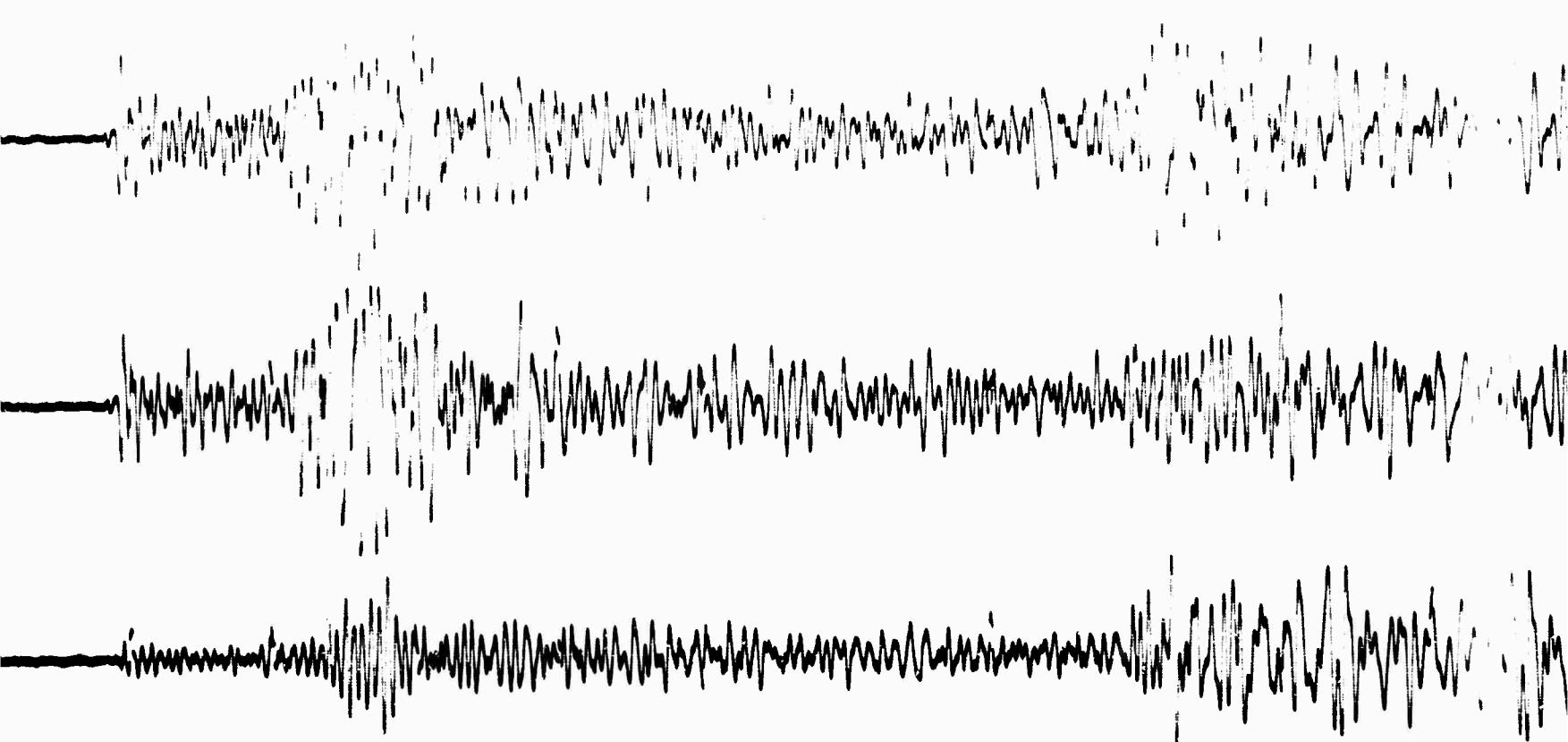
Campo, California

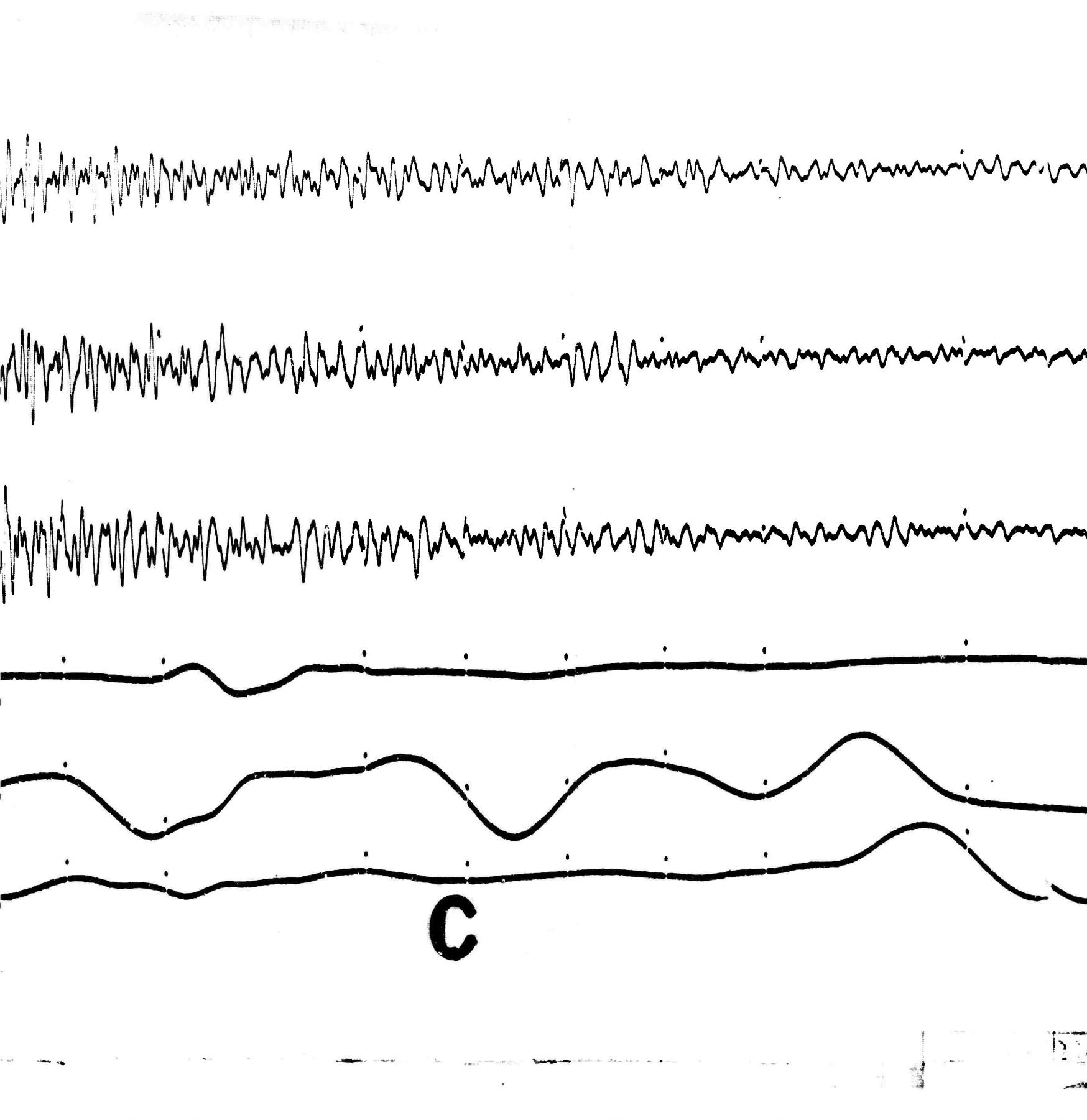
20 February 1964

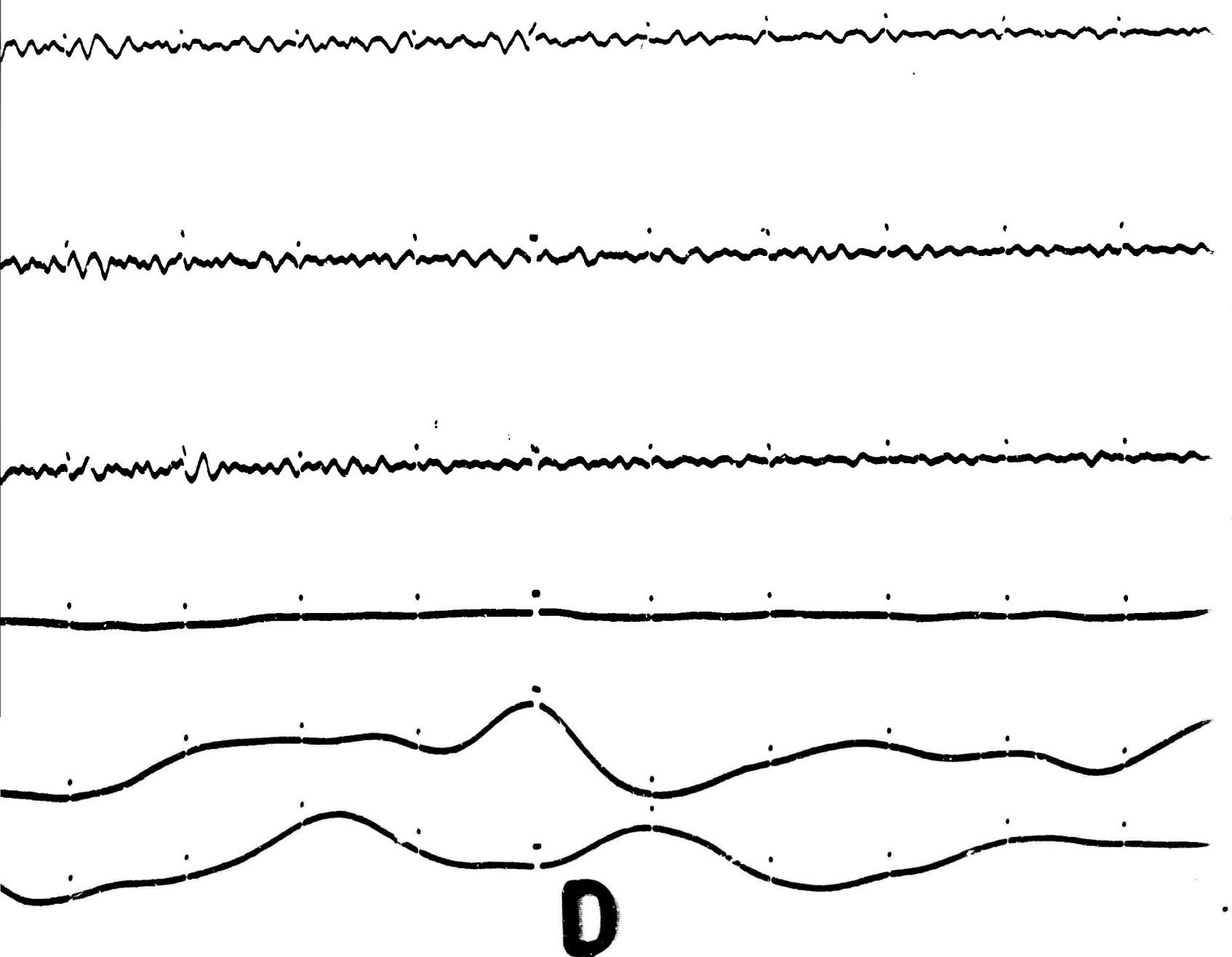
$\Delta = 491$  km

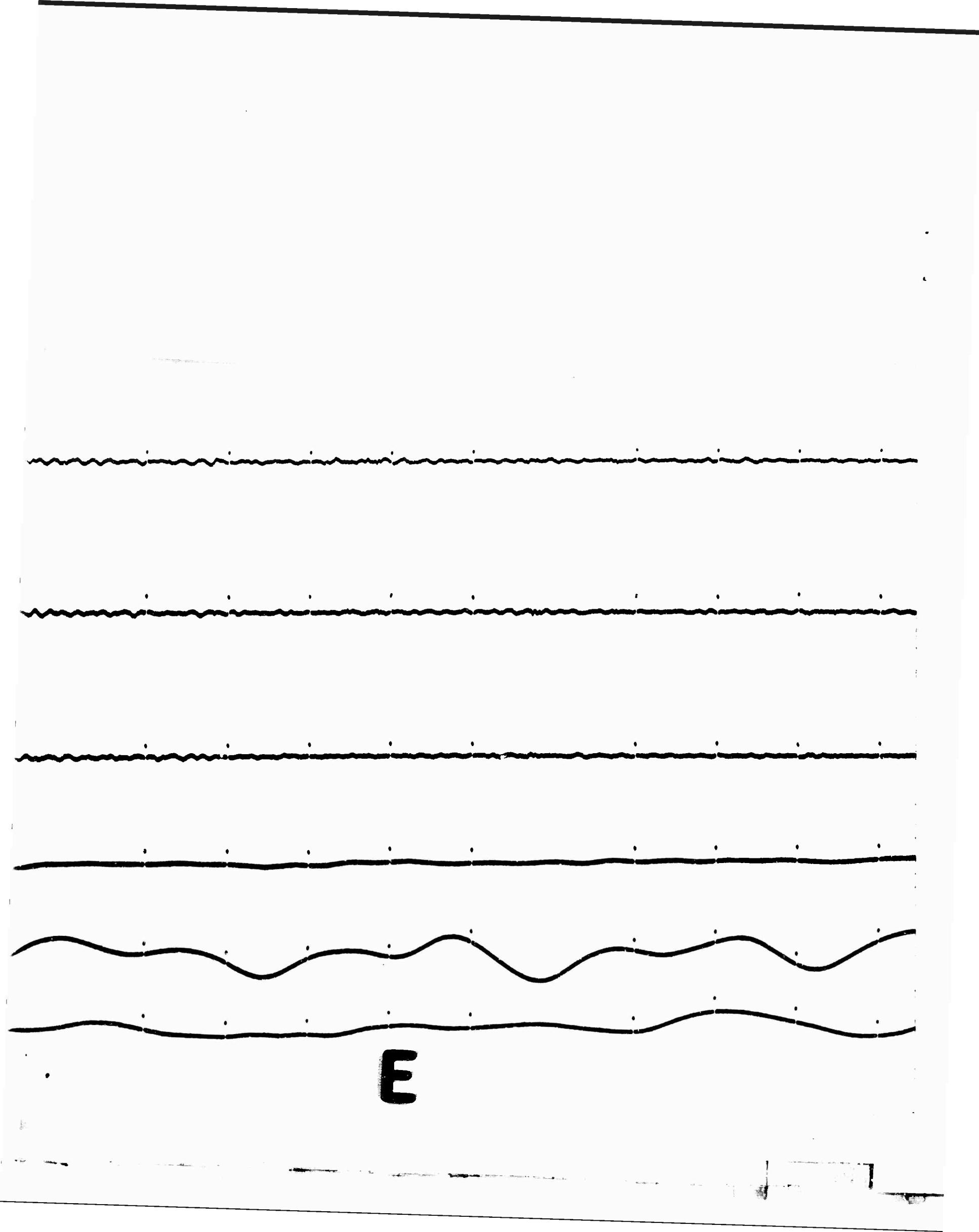


**A**









Unclassified

Security Classification

**DOCUMENT CONTROL DATA - R&D**

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) UED EARTH SCIENCES DIVISION TELEDYNE, INC. ALEXANDRIA, VIRGINIA 22314	2a. REPORT SECURITY CLASSIFICATION Unclassified
2b. GROUP --	

3. REPORT TITLE

Long Range Seismic Measurements - KLICKITAT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Scientific Report

5. AUTHOR(S) (Last name, first name, initial)

Clark, Don M.

6. REPORT DATE 24 November 1965	7a. TOTAL NO. OF PAGES 21	7b. NO. OF REFS 1
8a. CONTRACT OR GRANT NO. AF 33(657)-12447	8b. ORIGINATOR'S REPORT NUMBER(S) SDL Report No. 131	
a. PROJECT NO. VELA T/2037	8d. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) --	
c. ARPA Order No. 624		
d. ARPA Program Code No. 5810		

10. AVAILABILITY/LIMITATION NOTICES

Qualified users may request copies of this document from DDC

11. SUPPLEMENTARY NOTES --	12. SPONSORING MILITARY ACTIVITY ADVANCED RESEARCH PROJECTS AGENCY NUCLEAR TEST DETECTION OFFICE WASHINGTON, D. C.
-------------------------------	---

13. ABSTRACT

An analysis of seismological data from an underground nuclear explosion as a continuing study to provide information to aid in distinguishing between earthquakes and explosions. A table of travel-times and amplitudes of P, Pg, Lg, and surface waves are included along with other unidentified phases.

## Unclassified

## Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Seismic Magnitude						
Seismic Travel-Time						
Seismic Amplitude						
VELA-UNIFORM						
Nuclear Tests						

## INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization (corporate author) issuing the report.

2a. REPORT SPECIFICATION CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DOD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers (either by the originator or by the sponsor), also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those

imposed by security classification, using standard statements such as:

- (1) "Qualified requesters may obtain copies of this report from DDC."
- (2) "Foreign announcement and dissemination of this report by DDC is not authorized."
- (3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through \_\_\_\_\_."
- (4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through \_\_\_\_\_."
- (5) "All distribution of this report is controlled. Qualified DDC users shall request through \_\_\_\_\_."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring (paying for) the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as (TS), (S), (C), or (U).

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.